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ABSTRACT

This 2-year study examined how assistive technologies are used in educational programs for children who have significant multiple disabilities. Naturalistic inquiry incorporated qualitative collection procedures including observations, videotapes of children, and questionnaires and interviews with teachers and parents. Three groups of children were studied. The children had used technology applications in early intervention programs or received technology assessments and follow up as part of related projects. Case studies were developed on 14 children who had from 2 to 10 years experience with assistive technology when the study began. Findings indicated that assistive technology has positive effects on children's development even when they have significant disabilities and their technology experiences are inconsistent. Generally, children were able to use technology tools to accomplish tasks they would not otherwise have been able to do because of the severity of their disabilities. Improvement in social and emotional development was also related to technology use. Additionally, parents and service providers perceived that using assistive technology produced positive effects on the children's academic skills. Obstacles in obtaining, implementing, and maintaining access to assistive technology are noted, including problems of funding, personnel training, and collaboration among staff and between staff and families. Appendices include site descriptions and questionnaires. (Contains 68 references.) (DB)

State of Practice: How Assistive Technologies Are Used in Educational Programs of Children with Multiple Disabilities

ED 378 721

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A Final Report for the Project

Effective Use of Technology To Meet Educational Goals of Children with Disabilities

PR #180R10020
CFDA 84.180R

Funded by

Technology, Educational Media, and Materials for Individuals with Disabilities Program
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Patricia L. Hutinger, EdD.
Principal Investigator

Western Illinois University
Macomb, IL 61455
309/298-1634

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State of Practice: How Assistive Technologies Are Used in Educational Programs of Children with Multiple Disabilities

Abstract

The purpose of a two-year study conducted by Macomb Projects in the College of Education at Western Illinois University was to describe and explain how assistive technologies were used in educational programs for children who have significant multiple disabilities which hinder their interactions with people, objects, and events in their environment. Results demonstrated the state of practice of technology use.

A modified longitudinal approach permitted study of changes seen in the children, who participated in a variety of assistive technology experiences as they moved through school. The effects of technology applications and barriers to the achievement of the children's educational goals were examined. Naturalistic inquiry, incorporating qualitative data, offered the most appropriate assumptions and strategies for describing the ecology of the widely differing children. Data collection procedures included observations, videotapes of children as they used assistive technologies, questionnaires and interviews with teachers and parents, as well as other relevant materials.

Three groups of children were studied. They had used technology applications in early intervention programs or received technology assessments and follow-up associated with activities carried on by Macomb Projects. All children had severe multiple disabilities. Families and staff participated in the study. Case studies were developed on 14 children who had from 2 to 10 years experience with assistive technology when the study began.

Findings indicate that assistive technology use has positive effects on children's development, even when they have significant disabilities and when technology experiences are inconsistent as children move from program to program. Generally, across cases, the children were able to use technology tools at the end of the study to accomplish tasks they had never been able to do because of the severity of their disabilities. Children in all three groups exhibited the greatest improvement in social and emotional development as a result of technology use. Improvement was also noted across developmental domains of cognition and communication. Additionally, parents and service providers perceived that using assistive technology produced positive effects on the children's academic skills. Findings are reported related to educational objectives for using technology and the variety of obstacles in obtaining, implementing, and maintaining assistive technology for the children. Funding and personnel training presented major barriers as did issues related to collaboration among staff and between staff and families.

Table of Contents

Abstract i
Table of Contents ii
Introduction 1
Related Literature 2
Effects on Young Children 4
Children with Mutiple Disabilities 5
Families and Technology 6
Factors that Affect Technology Use 7
Macomb Projects Technology Resources 8
Method 8
Design 9
Subjects 10
Procedures 13
Case Study Summaries 18
Group I 18
Group II 26
Results and Discussion 32
Placement and Transitions 34
Technology Use in Educational Settings 35
Effects of Assistive Technology 47
Challenges and Barriers 54
Implications and Recommendations 64
Educational Use of Assistive Technology 66
Equipment and Software 69
Recommendations 70
Need for Further Research 73
Summary 74
References 76

State of Practice: How Assistive Technologies Are Used in Educational Programs of Children with Multiple Disabilities

By
Patricia Hutinger, Sharon Hall, Joyce Johanson,
Linda Robinson, Robert Stoneburner, and Kim Wisslead

Dear Papa
I thank you for my computr.
I lik having it at my hous!!!!!!!!
It was cold her.
Love,
Beth B.

Although 8-year-old Beth has been using a computer at home since she was 5, the 1993-94 school year marks the first time her school program has made it possible for her to consistently use a computer during the school day. Before this, her access to a computer was erratic since the equipment was in a computer center and only available at certain scheduled times. The software used was drill and practice and inappropriate for Beth's interests and developmental level. According to her diagnosis, Beth has cerebral palsy together with ambylopia and learning disabilities. Her family has gone to considerable length to make sure Beth gets the services she needs, including obtaining an advocate. At the beginning of the 1993-94 school year she refused to attempt to write her assignments. But when she finally was provided with a computer, Beth willingly wrote letters and stories. When Beth's mother asked her if using the computer was hard, she said, "No. It's hard when the kids can't read my writing. I just scribble scrabble. Now they can read my writing."

The major purpose of this chapter is to report the results of a two-year study[1] to describe and explain how assistive technologies[2] are used in educational programs for children such as Beth who have significant multiple disabilities which hinder their interactions with people, objects, and events in their environment. The findings represent the state of practice rather than the state of the art regarding assistive technology use.

Changes seen in the children, who participated in a variety of assistive technology experiences as they moved through school, as well as the effects of technology applications and barriers to the achievement of the children's educational goals were examined using a modified longitudinal approach. At the end of the study's observations, case studies were developed on 14

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[1]This study was carried out under the auspices of the U.S. Department of Educations, Office of Special Education and Rehabilitation Services, Technology, Educational Media, and Materials Program for Individuals with Disabilities Program, PR# H180R10020.

[2]"Assistive technology" refers to those devices and applications which increase, maintain, or improve the functional capabilities of children with disabilities. Those of particular interest to this study included computers, alternative input and output, software, dedicated augmentative communication devices, and services. The term is used interchangeably with "technology."

children who had from 2 to 10 years experience with assistive technology when the study began. Segments of case studies are used as illustrations in this chapter when they illuminate the findings. A naturalistic inquiry approach incorporating qualitative data was used because it offered the most appropriate assumptions and strategies for describing the ecology of the widely differing children. Data collection procedures included observations, videotapes of children as they used assistive technologies, questionnaires and interviews with teachers and parents, as well as other relevant materials.

The children in all of the three groups in the study used technology applications in early intervention programs or received technology assessments and follow-up associated with activities carried on by Macomb Projects[3] in the College of Education at Western Illinois University through Projects TTAP[4] and ACTT[5]. All children had severe multiple disabilities. Group I children began using technology as a result of recommendations from a TTAP technology assessment, and prior to the beginning of the study's observations, had 4 months to 4 years experience with technology. The older children in Group II began their assistive technology use in ACTT early intervention sites; however, by the beginning of the study, they had moved on to other placements. They had used technology for 3 to 8 years prior to the observations' beginning. Families and staff in both groups participated in the study. Group III children were assistive technology users from six ACTT replication sites in four states and Canada.

Results indicate that assistive technology use does have positive effects on children's development, even when they have significant disabilities and when technology experiences are inconsistent as children move from program to program. Generally, across cases, the children were able to use technology tools at the end of the study to accomplish tasks they had never been able to do without technology because of the severity of their disabilities. Children in all three groups exhibited the greatest improvement in social and emotional development as a result of technology use, according to their families and staff. These were the people who knew the children best and lived with them day to day. Improvement was also noted across developmental domains of cognition and communication. Additionally, parents and service providers perceived that using assistive technology produced positive effects on the children's academic skills.

Findings related to the educational objectives of technology use demonstrate differences between planning and outcomes as well as between staff and families. Staff in all groups tended to

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[3]Macomb Projects are comprised of a group of state and federally funded early childhood projects under the direction of Patricia L. Hutinger which focus on model program development, product development, and staff development related to young children with disabilities and their families. Assistive technology is a major emphasis.

[4]TTAP refers to the Technology Team Assessment Process, an Early Education Program for Children with Disabilities Model Demonstration Project. PR# H024B90038.

[5]ACTT refers to Activating Children Through Technology, originally a Model Demonstration Project funded by the Handicapped Children's Early Education Program in 1983, now an Outreach Project funded by the Early Education Program for Children with Disabilities. PR# H024D20044.

use a computer and peripherals for cognitive purposes rather than for development in other domains, even though they reported the greatest benefits in social and emotional development. Parents of Group I children saw computer applications as developing social and emotional skills rather than cognitive skills; however, parents of the Group II children viewed computer applications as building social and emotional and cognitive skills equally. Group III parents placed the most emphasis for technology use on motor development.

Families and staff encountered a variety of obstacles in obtaining, implementing, and maintaining assistive technology for the children. In particular, financial factors, limited training, and equipment constraints affected the quality of assistive technology services received by the children. Changes in placements, as well as lack of communication and collaboration between schools, also created obstacles. Some staff were uncomfortable with or disinterested in technology use. Others were unable to increase their skill level because staff development opportunities were scarce.

Although contemporary assistive technology applications hold the potential for giving children with disabilities a set of tools to access people, objects, tasks, and events in ways that were not possible 15 years ago, the findings of this study indicate that in many ways the potential is not being fully addressed. For example, electronic augmentative communication devices are likely to be used for speech and language lessons, but not for routine classroom communication. The advent of more powerful and relatively less expensive computers, together with alternative input and output devices, offer children with severe and multiple disabilities the means to interact with their environment when appropriate software is available and used. Unfortunately, many times these tools are not being used to help children reach their fullest potential in day to day programs, at home, and in the community.

Related Literature

The use of technology with young children with severe disabilities is a relatively new field of study (Behrmann, 1989). Opportunities to "control" events via technology early in life reportedly provide young children with skills and expectations they seldom acquire if they have no means to access their world (Behrmann, 1984; Behrmann & Lahm, 1983; Brinker, 1984; Brinker & Lewis, 1982; Hutinger, 1987a; Spiegel-McGill, Zippiroli, & Mistrett, 1989; Rosenberg & Robinson, 1985; Sullivan & Lewis, 1988, 1990).

The power of technology for changing education, which includes special education, has been noted by many. For example, the 1993 Illinois State Board of Education (ISBE) technology policy study notes that the potential of technology for transforming education and improving student learning cannot be realized if students, teachers, and administrators do not have meaningful

access to technology. Recognizing that there are differences of opinions as to what constitutes "meaningful access," the statement goes on to say that there is widespread agreement that it is not sufficient for technology to be provided down the hall in a special lab or to be used only for teacher demonstrations. If student learning is to be improved, teachers must know how to use technology and it should be incorporated into the existing curriculum. The conclusion of the policy study emphasizes the technology's potential for transforming education:

> *...technology -- particularly the new and emerging technology which is characterized by interactivity -- has a unique potential to help create real change in education. Implemented with care and imagination, technology can be more than a resource or support for traditional learning; it can be a means for restructuring the learning process and more effectively meeting student needs...* (p.2)

Effects on Young Children

Young children with severe disabilities can use computer technology to produce interesting events (Butler, 1988; Rosenberg & Robinson, 1985; Robinson 1986a & 1986b); to manipulate contingencies (Butler, 1988; Brinker & Lewis, 1982; Sullivan & Lewis, 1988, 1990); to select activities or objects (Behrmann & Lahm, 1984a & 1984b; Locke & Mirenda, 1988); to interact socially (Podmore & Craig, 1989; Spiegel-McGill et al., 1989); to operate devices in their environment and to communicate (Herman & Herman, 1989; Hutinger, 1986a & 1986b; Meyers, 1984, 1990; Muhlstein & Croft, 1986; Shane & Anastasio, 1989; Spiegel-McGill et al. 1989); and to solve problems (Hutinger, 1987b; Wright & Samaras, 1986). A few studies address the use of computers as learning tools for young children (Brinker & Lewis, 1982; Fazio & Rieth, 1986; Hooper & Warren, 1985; Hooper, Hamlett, & Hasselbring, 1985).

Several computer-based projects now work with young children with disabilities and their families, including **Projects ACTT** (Hutinger, 1993) and **CAPSULe** (Hutinger, Johanson, & Clark, 1993) in Macomb Projects, **Project Participate** which was developed by Steve Rosenberg and colleagues in Omaha, Nebraska; **Compuplay** and **Innotek** in Chicago; **Special Friends** in New York; **UCLA Intervention Program for Handicapped Children** in Los Angeles, **Teaching Learning Collaboration (TLC)** operated by United Cerebral Palsy, and projects at Vanderbilt University and the University of Illinois, Circle Campus, Chicago. Brinker continued his work with contingency intervention (personal communication, July 10, 1991) until his untimely death in the fall of 1993. Lewis and his associates (Sullivan & Lewis, 1988) remain active in studying the effects of contingencies and computer applications on infants and toddlers with disabilities. Sullivan and Lewis summed up their positive findings related to computer-based contingency intervention:

...we are quite encouraged by the preliminary evidence of positive outcomes. . . the response of the families to the program has been more positive than anticipated. . . Indeed we must consider that one major effect of the contingency intervention program is on the perceptions and attitudes of parents to their disabled children (p. 16).

Technology applications tend to enhance children's communication both as a tool for communication and as a topic of communication. When used with an additional speech synthesizer or internal speech, a computer provides a voice for communication or for language simulation activities. Combined with graphics and animation, the added component of speech output is an important contributor to communication development (Meyers, 1986, 1990; Shane & Anastasio, 1989).

Computer use fosters gains in emotional and social development. As a child successfully uses computer applications and becomes increasingly competent, feelings of self-confidence and self-esteem result and the child gains a sense of autonomy (Barnes & Hill, 1983; Brady & Hill, 1984; Swigger & Swigger, 1984). The computer is also a tool for enhancing social interaction and cooperation (Clements & Nastasi, 1985; Mulhstein & Croft, 1986; Muller & Perlmutter, 1985). Computers have the potential to equalize play opportunities and allow children with disabilities to participate with their non-disabled peers (McCormick, 1987) while various software programs can be used to promote turn-taking, group interaction, and problem-solving (Church & Glennon, 1992). Spiegel-McGill, Zippiroli, and Mistrett (1989) found positive results when children with significant social interaction deficits and speech and language delays played on a computer with socially competent peers who did not have disabilities. Clements (1987), referring to children's use of Logo, points out that the computer encourages as well as benefits both social and cognitive interactions.

Evaluation studies of children in preschool programs for youngsters with disabilities conducted by ACTT staff indicated that preschoolers can learn to use computers successfully when presented with the curricular approach provided by ACTT (Hutinger, 1987a; Hutinger & Ward, 1988; Perry, Ward and Hutinger, 1987). In an effort to demonstrate child progress over time, the impact of weekly computer interventions on preschool children with mild to moderate disabilities over a six-month period was measured. Using a pre- and post-test design, the study focused on a child's knowledge of Logo and the ability to apply this knowledge in solving mazes, a task that is used to measure problem solving ability. Four area school districts participated in the study. Forty-three children aged 3-5 participated, with an experimental group of 24 and a control group of 19. Test items analyzed for this study included both interview and demonstration items. The experimental group showed significant improvement from pre- to post-testing on maze performance, $F(1,34) = 27.121$, $p<.001$. ACTT evaluation data also suggest that children with mild to moderate disabilities retain the ability to use Logo over a six-month period, including

summer months, when they either do not have access to computers or when they are engaging in other computer applications (Hutinger, 1987b).

Children with Multiple Disabilities

Technology use for children with multiple disabilities tends to be used to remedy impairments and to assist individuals learn and/or perform tasks (Garner & Campbell, 1987). It provides learning situations in which the children manipulate their environments and develop understanding of their abilities to control these environments (Brinker & Lewis, 1982; Parette & VanBiervliet, 1991), communication (Traynor & Beukelman, 1984), mobility (Butler, 1988; Holder-Brown & Parette, 1992), and age appropriate living skills (Esposito & Campell, 1987). Of all the skills developed through the use of technology, Schweigert (1989) considers understanding the relationship between behavior and environment outcomes to be critical for all future learning.

Families and Technology

Swartz (1993) reported on a survey conducted with 234 parents of children with disabilities to "collect and examine current information about the use of technologies, at home, by children and youth with disabilities; the kinds of service and assistance families believe promote that use; and, parents' expectations regarding child outcomes from technology use" (p. 70). All families had contact with resource centers affiliated with the Alliance for Technology Access and 84% of 232 families responding had computers in their homes. The other 16% had some type of technology available at home. Responses from families demonstrated that parents have greatest expectations for technology to assist in improving their children's academic achievement, followed equally by improvements in self-esteem and confidence and vocational/career opportunities, improved use of recreational time, and improved emotional adjustment and mood. However, reports only from fathers indicated they were significantly less optimistic in their expectations for technology use.

Swartz also confirmed the need for collaborative planning to support the individual needs of families (p. 120). This support includes relieving stress associated with acquiring technology literacy, financial considerations involved with acquiring equipment, and equity of access (p. 125). Swartz cautioned that a home-school collaborative model must acknowledge that technology use is a tool and not a panacea for children with disabilities (p. 126).

To be most effective, technology applications for children with disabilities must be planned to assist them achieve specific goals and must be implemented as a tool to accomplish these goals. A multidisciplinary approach which includes input from the child's parents is necessary for

selecting appropriate devices and planning consistent implementation across all environments (Holder-Brown & Parette, 1992).

Factors that Affect Technology Use

Okolo, Bahr, and Rieth (1993) analyzed the last 10 years of literature about computer-based instruction (CBI) for students with mild disabilities. They found five factors that have affected the use of CBI including "(a) unrealistic expectations of outcomes, (b) limited access to hardware and software, (c) classroom constraints, (d) limitations of existing research synthesis, and (e) other research limitations" (p. 1). Despite these issues, computer use has effected changes in the teacher's role in the classroom, the content and practice of teaching, and influenced the way students learn. Four factors appear especially important for the effective use of CBI for mildly disabled students. These are "(a) effective software designed to conform to the computer's characteristics, (b) effective CBI programs that follow generic principles associated with effective teaching and learning, (c) effective software incorporating a model of instruction that is appropriate for teaching a particular skill, and (d) the degree of control learners have over CBI" (p. 11). Over the past decade, the "focus of computer applications has changed from emphasizing drill and practice...to supporting knowledge construction and higher order thinking skills" through use of application software (e.g., databases, word processing, and "computer- mediated text") (p. 18). However, students will not benefit from these applications without the assistance of a well-trained and sophisticated teacher.

Sherer and McKee (1992) point out that using assistive technologies creates challenges as well as benefits. Funding assistive technology devices (Parette & VanBiervliet, 1991; Holder-Brown & Parette, 1992) and lack of appropriate software (Reeson & Ryan, 1988) are major barriers, as are lack of training and resource information, lack of appropriate devices, and lack of resources to maintain equipment (Parker, Buckley, Truesdell, Riggio, Collin, & Boardman, 1990). When teachers of children with multiple disabilities ranked four essential services that would help them overcome these barriers, they listed technology assessments to assist in selecting appropriate devices, training for technology use, additional information about technology, and staff responsible for equipment maintenance. Their solutions for these barriers were on-site training, a technology resource center for parents and staff, and a technology resource specialist providing services on-site (Parker et al., 1990).

Macomb Projects Technology Resources

The study reported here is based on Macomb Projects' rich history and use of adaptive devices and various computer applications with young children with disabilities that began in 1981. The children who participated in the study had been served by a component of Macomb Projects during a technology assessment, in a service delivery project, or in a replication site. Between 1981 and 1994, Macomb Projects successfully implemented eight major computer technology projects involving personnel preparation, demonstration, software development, and adaptations, including Project MUSE (Microcomputer Use in Special Education), MUSE Trainer, MicroApplications Training Modules, Project ACTT, PACT-ACTT Partnership, Project TTAP, the Technology Inservice Project (Project TIP), and Computer Applications for Preschoolers in the Springfield Urban League (Project CAPSULe).

In 1983, Macomb Projects staff began to investigate technology applications for young children in Project ACTT, a three year model demonstration project. ACTT successfully integrated a computer curriculum model, using affordable and practical hardware and software, into programs for young children from birth through 8 with disabilities, their families, and staff. ACTT developed an intervention component using computers, then demonstrated that adding such intervention to a traditional, ongoing early intervention program is both possible and useful.

Based on the success of ACTT, Project TTAP was funded in 1989 to develop a technology assessment model for children from birth through 8 who demonstrate moderate to severe disabilities that inhibit their interaction with people and objects in their environment. Both projects contributed to Macomb Projects' videotape bank, collected over the past 10 years showing computer intervention activities for 20 children with varying disabilities. However, the resources were unavailable to code behaviors and analyze changes shown on the videotapes. Some of these videotapes of the children in Groups I and II were studied for the present project.

Method

A naturalistic ecological systems[6] approach was used to study a broad range of outcomes including benefits, barriers, applications, management, and implications of technology use. This approach allowed the gathering and analysis of a wealth of information about Beth as well as other children. The children in the study have unique stories containing elements that reflect the impact of technology on them and on their families and school staff. Families, teachers, intervention team

[6]The terms 'ecological system' refers to the variety of internal and external factors that interact and transact with children and adults as they conduct the activities of daily life.

members, public and private agency personnel, and other significant 'players' participated in the study.

Design

The study, which focused on long-range use of technology over time on young children with severe disabilities, their families, and relevant aspects of the child's ecological system, had four major goals: 1) to describe how assistive technologies are used in educational and related settings including teaching content, skills, and strategies.; 2) to describe the effects of assistive technology use; 3) to analyze the benefits, challenges and barriers related to assistive technology use; and 4) to determine the implications for assistive technologies use in the education of children.

A modified longitudinal approach permitted study of changes seen in the children who participated in various assistive technology experiences as they moved through school. Data were collected over a two-year period from three groups of children who used technology applications, their families, and the professionals involved in the children's education. However, data since the children first began using technology in early childhood programs was integrated to build a story about what happened to technology-using children and their families over time. In the same manner, follow-up data was included when it provided further insight to the child's story.

Based on a naturalistic paradigm, the study used the qualitative principles detailed by Bogdan and Biklen (1982), Filstead (1970), Lincoln and Guba (1985, 1989), Merriam (1988), Patton (1980), Tesch (1990), and Yin (1984). The data collection methods were qualitative within the framework of a holistic-inductive design of naturalistic inquiry, and content or case analysis. The approach differs from the traditional quantitative experimental design in underlying assumptions about sampling, the role of the researcher, the nature of the data, the process of data collection and data analysis.

The approach required rigorous data collection procedures, including observations of a relatively small number of children with severe disabilities, families, and staff rather than standardized quantitative tests and measures and tight experimental control of a large sample. The unit of measurement was the individual child together with the family and professional staff. Qualitative assumptions are appropriate to the issues and procedures related to technology use by young children with widely varying disabilities, family values and characteristics, as well as context, social and political concerns.

Descriptive case studies of the 14 children in Groups I and II were compiled. Rigorous documentation of observations of children, staff, families and other professionals; interviews; examination of records and materials; analysis of videotapes; content analysis and other methods

were used rather than experimental treatment, standardized tests, and parametric statistics. Neither experimental treatment nor standardized measurement tools such as test scores were used to determine results.

The interactive constructivist process used includes the researcher and the many stakeholders (children, families, and staff) who are put at some risk by the study rather than by "facts" in an ultimate sense, or the "way things really work" (Lincoln & Guba, 1989, p. 8). The way people (families and staff) make sense of their situations, or construct their realities, (in this case, their child's disability and use of technology) are shaped in a major way by their values. Rather than one reality, families construct different realities, as do team members and school staff, factors taken into account in the present study.

Subjects

The subject sample recruited for the study was purposive in nature, chosen to represent a group of children who received assistive technology intervention as young children and who used various applications as a result of participation in Macomb Projects' technology intervention or assessment activities. Purposive sampling is recommended by Lincoln and Guba (1985) and Patton (1990) in order to secure the very best possible data sources.

The **target population** for Groups I and II were all children with disabilities between the ages of 2 and 14 residing in western Illinois who had been served in ACTT technology intervention programs or had received technology assessments from TTAP. The families and service providers were included in the target population. This group consisted of 798 children, their families, and 152 service providers at sites which replicated the ACTT curriculum model. It also included 51 children who had received a TTAP technology assessment, their parents, and service providers. The target population for Group III was all parents, children, and staff served at the 57 ACTT replication sites in 14 states and Canada, excluding sites in western Illinois being considered for Group II sites. This included 4525 children, their families, and 760 service providers.

The **accessible population** for Groups I and II were 33 children between the ages of 2 and 14 residing within western Illinois who had received early intervention services from ACTT or technology assessments from TTAP. The accessible population for Group III was the parents, children, and staff served by six randomly selected ACTT replication sites. This population included 423 children, their families, and 96 service providers.

The **invited sample** for Group I and II consisted of 15 children between the ages of 2 and 14 who met the following criteria: 1) had received early intervention services from ACTT or technology assessments from TTAP, 2) resided within 100 mile radius of Macomb, 3) had

technology applications available, and 4) had families and service providers who agreed to participate in the study. The invited sample for Group III consisted of 27 young children, nine mothers, and 19 site staff or coordinators. The criteria for inviting this sample included the following: 1) used technology in their program, 2) agreed to participate in the phone interviews and questionnaire activities, and 3) participated in ACTT replication sites.

The **data-producing sample** for Group I and Group II originally included 15 children between the ages of 2 and 14 who had early technology intervention services, 14 mothers (two of the children were twins), one father, two grandmothers, one grandfather, 15 special education teachers, six regular education teachers, one vision specialist, seven school speech therapists, one private speech therapist, one public school administrator, one private school administrator, one occupational therapist, one physical therapist, one occupational therapy assistant, one physical therapy assistant, and 12 classroom aides. One child was withdrawn from the study during the first 3 months because his teacher declined participation. The data-producing sample for Group III originally consisted of 27 children, 9 family members, and 19 site staff or administrators, but the sample fluctuated as the study progressed.

The 14 children in Groups I and II were enrolled in 11 school districts in western Illinois located within a 100 mile radius of Macomb. These 11 districts ranged in size from 60 students to 7,960 students. Ten were K-12 districts. The smallest was a K-6 district. Three of the 11 districts were in counties identified by the U.S. Department of Management and Budget as metropolitan counties, while the other eight districts were in non-metropolitan counties.

Table 1 illustrates the nature of the Group I and II children's disabilities, their ages when they were first introduced to technology applications, and their ages at the beginning and end of the study. All of the children in the study were diagnosed as having significant multiple disabilities. According to their medical diagnoses, most exhibited at least four disabilities each, including cognitive, orthopedic, communication, sensory, or behavioral impairments. Ten of the children had disabilities that severely restricted their ability to communicate. Four children in each group were non-verbal, while two other children had delayed language or language that was unintelligible to communication partners who were unfamiliar with it. Behavior problems included noncompliance (e.g., not following a specific request from an adult) and inappropriate touching (e.g., pinching or touching another child after being told to stop). Six of the children, subject to seizures, took medication for the disorder.

Group I

The first group included seven young children with multiple disabilities, four girls and three boys, who had TTAP assessments and then began to use technology applications. The

children ranged in age from 2 years to 8 years when the study's observations began. Eight family members and 21 professionals who provided the child's educational experience were included.

Table 1. Children's Diagnoses and Ages in Relation to Their Introduction to Technology and the Research Study

	Diagnoses	Age Introduced to Technology	Age at Beginning of Observations	Age at End of Observations
Group I				
Anne	Spastic Tetraparesis Seizures	1 year	5 years 1 month	6 years 9 months
Beth	Cerebral Palsy Ambylopia Learning Disabilities	5 years 8 months	6 years 5 months	8 years 1 month
Cathy	Seizures Severe Mental Retardation	4 years 10 months	5 years 8 months	7 years 4 months
David	Tricuspid Atresia	3 years 4 months	3 years 8 months	5 years 4 months
Eric	Cerebral Palsy	4 years 5 months	8 years 9 months	10 years 5 months
Faith	Shaken Baby	1 year 6 months	2 years 8 months	4 years 4 months
Gary	Developmental Disabilities Right Hemiparesis	5 years	7 years 10 months	9 years 6 months
Group II				
Hugh	Cerebral Palsy Hydrocephalus	4 years 2 months	8 years	9 years 8 months
James	Cerebral Palsy Visual Impairment Learning Disabilities	4 years	13 years 2 months	14 years 10 months
Kenny	Cerebral Palsy	3 years 11 months	7 years 3 months	8 years 11 months
Lynn	Severe Mental Retardation	3 years 10 months	10 years 9 months	12 years 5 months
Nathan	Cerebral Palsy	3 years	11 years 9 months	13 years 5 months
Mark	Cerebral Palsy Hydrocephalus Visual Impairment Severe Mental Retardation	3 years	11 years 9 months	13 years 5 months
Paul	Cerebral Palsy von Willebrand's Disease Severe Mental Retardation Seizures	9 months	7 years 6 months	9 years 2 month

* February 1992 is the beginning date of the observations. Observations were conducted over a 20-month period.

Group II

The second group, comprised of one girl and six boys, ranged from ages 7 to 13. Group II children had used technology applications for 3 to 8 years since beginning assistive technology use in intervention programs at ACTT sites; however, their placements had changed by the time the study began. This group also included 9 family members and 15 professionals. Group II provided both a historical perspective and a description of present assistive technology use.

Group III

The third group, drawn from six randomly selected ACTT replication sites in four states and Canada, consisted of 19 early intervention site staff and administrators, 9 family members, and 27 children -- 16 boys and 11 girls -- ranging in age from 1 to 14. The children's disabilities, which included cognitive, orthopedic, sensory, communication, and seizure disorders, were similar to the disabilities in Groups I and II. Data collected from Group III interviews was used to compare and contrast with the information collected in Groups I and II.

The six sites selected for Group III interviews included: 1) Parent-Child Development Center (Hawaii), 2) Leeward Infant and Toddler Development Center (Hawaii), 3) Society for Manitobans with Disabilities (Canada), 4) Signal Centers (Tennessee), 5) Quincy School for the Handicapped (Illinois), and 6) Educational Service Center in Corpus Christi (Texas). Descriptions of these sites are found in Appendix A. Supplemental interviews to obtain a state-level perspective on assistive technology use were also conducted with the Program Specialist for Computer Support from the State of Hawaii Health Department Zero-to-Three Hawaii Project and Coordinator of Hawaii's state-wide replication of ACTT's Birth to Three curriculum.

Procedures

The children in Groups I and II were observed regularly at school and at home. Changes in observation schedules were made due to illness, surgery, conflicting family schedules, holidays, and winter weather. On-site observations were videotaped and used as data sources and checks. Detailed field notes were maintained. Case studies were developed for each child. Staff and families were interviewed informally at each observation. Group III participants were interviewed by phone.

Initial Activities

Children in Groups I and II were identified; then participation agreements and appropriate release forms were secured from parents. Rapport was established through telephone contacts and site visits. Prior to observations, the classrooms and homes of the children were visited in order to "learn the culture" and gain acceptance and trust. General information about the study was given to participants who were encouraged to ask any questions to clarify the purpose of the study and their roles as participants. Before field observations began, TTAP and ACTT child and family records and videotapes of the children's assessments or early experiences with technology activities were reviewed.

Interviews

Individuals in all three groups were interviewed during the study. Sample interview forms are shown in Appendix B. Individual interviews ranged from 15 minutes to 3 hours. An average of 10 hours of interviews was collected for each child in Groups I and II.

Parents, teachers, other significant adults, and children in Groups I and II were interviewed informally after each observation, while formal interviews were scheduled throughout the study for family members and staff. Two children were interviewed; the others had significant speech and language impairments. Macomb Projects staff who worked with the children and families either in ACTT or during technology assessments were also interviewed, guiding the research team to appropriate videotapes of the children when they began technology use and discussing the nature of their ongoing contacts with the children, families, and staff prior to the research study and after the study discontinued observations.

Before the initial interviews with Group I and II participants, the interview forms were piloted with parents who were not part of the study sample. Research staff rehearsed the interview process through role playing. During the first site visits, family members and teachers were interviewed on the medical, developmental, and educational history of the children. These formal interviews were recorded on audio tapes and transcribed. The interview transcriptions were returned to the respondents for editing as part of a "member check" process (Lincoln & Guba, 1985) to obtain accuracy and clarity of information. The member check is used "to obtain confirmation that the report has captured the data as constructed by the informants, or to correct, amend, or extend it, that is, to establish the credibility of the case" (p. 236). The respondents edited the information, signed the document when they finished, and returned it to the research team.

Three rounds of telephone interviews were conducted with Group III participants at six-month intervals. Eighteen Round 1 telephone interviews were conducted in June 1992. Initially site coordinators provided the names of 27 individuals who were invited to participate. Each was sent an interview form with a letter asking them to confirm a date and time when they could participate in a phone interview. Fifteen staff and three parents responded and were interviewed. Detailed notes made during each interview were transcribed and returned to the respondents as part of the member check process. The respondents edited the interviews and returned the copy with their comments and changes.

Round 2 interviews took place 6 months later in December 1992. Previous respondents were recontacted by mail, sent a copy of the revised interview instrument and a postage paid envelope, and given the option to complete the interview instrument as a questionnaire and mail it back rather than participate in the telephone interviews. However, only 20% chose this option. During the second round of telephone calls, four invited participants declined to participate in the

interviews. At that time the research team determined that new respondents were needed since staff and children had changed and the number of parental responses was small. During this round of interviews, previous respondents were asked to suggest the names of other staff members and parents who would be willing to participate in the study. A total of 20 interviews with 14 staff and 6 parents were then conducted during Round 2. Respondents were notified that they would be contacted again in 6 months.

Round 3 interviews began in June 1993. Previous respondents were recontacted by mail and by telephone. Interviews with 12 staff and 8 parents were completed.

Observations

All children were observed in their school placements twice each month at approximately two-week intervals for 20 months. They were also observed at home during school vacations. Individual observations ranged from 7 minutes to 1 hour, with the average observation lasting 30 minutes. Total observation time over the 20 months ranged from 8 hours (Gary) to 16 hours (Anne and Cathy). The average total observation time was 13 hours. In addition, the early videotapes of the Groups I and II children taken during their technology assessment or when they received early ACTT services were viewed.

Observations were as unobtrusive as possible to minimize the effect of the researchers on all the children in the classroom (Allen & Catron, 1990). Observations were scheduled at various times across the school day to include classroom instruction with and without technology and with support services' staff. Each observation was recorded on videotape (Hersen & Barlow, 1982). Detailed field notes were written (Bogdan & Biklen, 1982) which included an in-depth survey of vocalizations, social interactions, independence, prompting, reinforcement, and child affect data across all activities.

The videotaped segments varied in length due to scheduling factors in classrooms and homes as well as child and family activities. At each school observation, information was collected from teachers and/or service providers about their objectives for activities and the quality of the child's participation and interaction on that day. Follow-up interviews were conducted with the school staff regarding their overall training for service delivery, including assistive technologies, and their classroom practices related to scheduling, management of instruction, and collaboration with support services. When children changed school placements, all new school staff were interviewed with the same instruments used with the previous staff. The member check process was repeated to verify the interview data. During home visits, family members were also interviewed about their experiences with technology and their perceptions of school technology use.

Videotapes

Using videotapes of the child observations for accomplishing member checks was a unique and effective feature of the study. The videotapes also served as a basis to establish inter-rater reliability. The videotapes served as guides for acquiring new insight which led to further data collection. Later, segments of various observation videotapes of each child in Groups I and II were edited. A case study videotape of each child was made and shown to the child, the family and teachers or service providers.

Data Analysis

The naturalistic approach used in the study emphasized collecting, analyzing, and summarizing information recorded in field notes using coding systems, content analysis, and quantitative measures. Data related to the research questions were collected from descriptions of situational observations, interviews, videotapes, questionnaires, school records, child products, and other relevant materials. Constant internal checks on the rigor of data collection included staff auditing of all data as it was gathered.

Coding systems were developed for content analysis. The framework for procedures used during the process was based on Lincoln and Guba's (1985) protocols. The information for the initial content analysis was categorized on 3 x 5 cards as described by Lincoln and Guba (1985). During the final analysis, categories were found to effectively unify information across children and respondents, a procedure recognized by Tesch (1990, p. 119) as being appropriate. The data analysis was organized across variables that included age, gender, socio-economic status, diagnoses, the degree of impairment across disability categories, educational placement of children, training of service providers and families, types of assistive technologies available in the placements, and objectives for technology programming.

Lincoln and Guba (1985) suggest four ways to establish trustworthiness of the data: credibility, transferability, dependability, and confirmability. The credibility of the procedures was established through prolonged engagement, persistent observation, data triangulation, peer debriefing and member checking. Transferability was established through the accumulation of data to provide "thick description" (p. 316). Dependability was established by engaging a research consultant experienced in naturalistic inquiry to conduct an audit of the data collection process.

Confirmability of data was established by maintaining all collected data as an "audit trail" (Lincoln & Guba, 1985, p. 319). In addition to field data and videotapes, the research staff documented all research-related activities in a series of logs including a daily activity log, a methodological log, and a series of process memos. The research consultant conducted a "confirmability audit" (p. 318) on the data at the end of the first year and found that the "procedures were thorough and accurate. Data can easily be traced through videotape, transcripts,

summaries and case analysis" (Lombard, 1992). During a second audit, the auditor determined that "The logs, journals, tapes, and indexes kept by the staff made it easy to follow the data trail from the fieldwork through the final case studies" (Lombard, 1994).

A further measure to ensure accuracy of data was provided by inter-rater checks performed on the videotapes. Ten percent of the videotaped field observations were randomly selected for coding behavior across 10 categories including social interactions, vocalizations, independence, prompting, reinforcement, and child affect as the children engaged in technology activities. Inter-rater agreement ranged from 13 points difference to total agreement with an average across cases above 90%. Eighty percent agreement was the minimum standard for inter-rater reliability. When agreement fell below that level, further training was undertaken to minimize misunderstandings about the operational definitions of categories.

All interview information was member checked with the respondents to establish accuracy. Segments of videotape from the field observations were taken to the school and the home for viewing by the school staff, related service personnel, and parents. These individuals were asked to comment on their perceptions of the children's use of assistive technologies as seen on the tapes. The comments were recorded on audio tapes, transcribed, and returned for editing as an additional member check for accuracy.

Instruments

All interview instruments used with participants were developed by the research team. Selected instruments were reviewed and edited by the Expert Panel, described in a later section. Pilot interviews were conducted with parents and teachers who were not participating in the study to determine the effectiveness and clarity of the questions. A sample interview form on technology use for teachers and parents is shown in Appendix B.

Personnel

Research team members represented a variety of values and multiple disciplines, including psychology, special education, and sociology. Their varying levels of insight, expertise, and experience related to their respective disciplines were pooled to provide a team able to examine questions from more than one perspective.

Expert Panel

The seven-member Expert Panel included the mother of a child with multiple disabilities and six professionals whose areas of expertise were assistive technologies and/or special education. These professionals were members of university faculties at different locations in the east, midwest, and west. Panel members performed a variety of functions including reviewing

interview instruments and critiquing case studies. Three members whose schedules permitted -- Elizabeth Lahm, Cindy Okolo, and Michael Rettig -- met in Macomb to review drafts of the final report and make suggestions for changes, additions, and interpretations, prior to completion. Panel members included:

Rick Hemp, Assistive Technology Financing Project, University of Illinois at Chicago, Chicago, Illinois

Bob Kelly, Technology Specialist, Technology Center, University of Missouri at Kansas City, Kansas City, Missouri

Elizabeth A. Lahm, Assistant Professor, Center for Human disAbilities, George Mason University, Fairfax, Virginia

Cindy Okolo, Area Coordinator for Special Education for Department of Education Studies, University of Delaware, Newark, Delaware

Michael Rettig, Associate Professor, Special Education, Fort Hays State University, Hays, Kansas, and President, Exceptional Children's Software

Steve Rosenberg, Assistant Professor, Department of Psychiatry, University of Colorado, Denver, Colorado

Ruth Wilson, Parent of a child with cerebral palsy, Bushnell, Illinois

Case Study Summaries

A case study and a videotape summary was compiled for each of the 14 children in Groups I and II. Descriptions of the child's medical background, educational placements, and technology applications in the classrooms, related services, and at home were included. Qualitative data regarding technology applications for each child as seen by the significant individuals in their environments were an integral part of each case study. An edited case study was sent to each respondent as a final member check for accuracy and to determine consensus among respondents as recommended by Guba and Lincoln (1989). Summaries of each case study follow. Ages referred to at the beginning of each case study summary are the ages of the children when the observations began. Their ages at the end of the observations are shown in Table 1.

Group I

Children in Group I were assessed by TTAP. Across cases, some, but not necessarily all, of the adaptations and applications used followed the recommendations from TTAP. These

children were younger than Group II children and were at an earlier level of technology usage, with the exception of Gary who quickly became proficient with his Liberator™. All the children had participated in Birth to Three programs. The children had used technology applications from 4 months to 4 years when the study began.

Anne

Anne is described by her mother as a "normal 5-year-old" who loves hearing stories, riding her bike, and playing with a toy kitchen with her sister. She lives with her parents, and an older and younger sister. Since she has limited physical abilities, Anne needs assistance to participate in her favorite activities. She has spastic tetraparesis, a muscular weakness affecting all four extremities. Anne experiences seizures and physical symptoms which include low muscle tone, difficulty in controlling her head and eye movements, inability to suck, and inability to use verbal language. As a result Anne exhibits developmental delays across all domains.

Anne's family realized technology's potential when she was just 1 year old as she began using switches and toys at home. When she was 2 years old, her speech therapist introduced her to a dedicated speech device on an experimental basis. At 3, her family and Birth to Three interventionist became interested in Anne's potential for computer use. They requested a TTAP assessment to determine a suitable input method and to assess prerequisite skills for using a communication device. A head switch and simple switch-operated software was recommended to encourage cognitive skills and beginning scanning skills. A second TTAP assessment was done at 4 1/2 years to re-evaluate the input method, because Anne did not like to use the head switch with her peers at school. A hand-activated switch and computer activities were recommended to further Anne's cognitive skills.

Anne attended a self-contained "Severe-Profound" classroom in a center for individuals with developmental delays at 4 years. During the study she changed from this placement to a public school classroom for children with physical and/or health impairments at her family's request.

She had access to a variety of equipment at home, purchased through health insurance as well as fund raising efforts of the family and others when she was 4. The equipment consisted of a Light Talker™, later upgraded to a more sophisticated device (the Liberator), an Apple IIGS® computer, and peripherals, including an Echo Speech Synthesizer®, Adaptive Firmware Card™, Muppet Learning Keys®, two Big Red Switches, software, and adaptive equipment (aqua walker, potty chair, adaptive puzzles). Anne used beginning software, **Power in Play**, with her communication device, and simple causality software with her computer at home to help increase cognitive and communication skills. Her mother participated in two week-long computer training sessions conducted by Project ACTT staff to increase her skills in customizing home activities for Anne.

Anne took her Liberator to school daily and also brought switches that were used for input with software programs. Her classroom contained similar equipment to what she had at home, including an Apple IIGS computer, Unicorn Expanded Keyboard™, Adaptive Firmware Card, and various public domain software programs. However, the Echo Speech Synthesizer, an essential peripheral for communication, was not available for Anne at school. Therefore without speech output, the computer was used only for motor skills, and some cognitive skills, such as attending, but not as a communication tool.

During the study Anne used her Liberator at school most often during structured language activities in which she was required to find a specific picture on her overlay in response to the teacher's question. However her mother and teacher reported Anne's most enjoyable use of her Liberator was during "Calendar" activities at which time she pressed specific pictures on her overlay to share personal messages with her classmates. Messages about birthdays and other special events were programmed by her mother or her teacher. Anne used her communication device with a direct select method of input. Since scanning is another option for input, computer software was used to help reinforce beginning scanning skills. Although Anne was able to use a computer in the classroom to operate simple switch programs, such as **New Cause and Effect**, more sophisticated switch use is needed before Anne can effectively use a computer or her Liberator as communication tools through switch input.

Although there have been many barriers in Anne's technology use, including physical fatigue, behavior problems, occasional lack of interest, and equipment problems related to programming the communication device, her mother and teacher see many benefits for Anne. They both think that Anne has begun "to see the value of communicating and being able to communicate." Anne's mother has seen a change in the attitude of adults who view Anne now as a child with information to share rather than as a helpless infant.

Epilogue. Two problems, visual tracking and behavior, which had affected Anne's technology use throughout the study were improved during the 1993-94 school year. The visual tracking problem was corrected through eye surgery. Anne continues to use her Liberator with an eight choice overlay. During a recent visit to her classroom, Anne participated in a group activity in which the Unicorn Expanded Keyboard was used as a communication tool. She answered questions about a computer story on the program, **Storytime Tales**, by pressing the appropriate picture on the Unicorn overlay. Although Anne uses a computer and her Liberator, neither one of these tools have become a consistent part of her daily activities. While her mother sees technology as a "necessary part" of her life, there are still barriers which need to be addressed in order for Anne to effectively use technology for communication.

Beth

Five-year-old Beth has the distinction of being the first child with multiple disabilities to be served under "an inclusion model" of service delivery at her public school. Beth's diagnosis is cerebral palsy, developmental delays, and ambylopia that affects her left eye. She lives at home with her parents and a younger brother. When Beth was 4, her family was concerned about her ability to communicate verbally or through standard written methods. They requested a TTAP assessment to explore ways a computer could assist Beth at home and at school. Computer activities with speech output and keyboard or TouchWindow® input were recommended to encourage independence and self-direction.

Since that time Beth has been using a computer at home, beginning with a short-lived second-hand computer and software. Later she used an Apple II+® computer borrowed from a public service agency. Beth enjoys playing games, such as **Peanuts Picture Puzzlers**, with her brother, and showing other children how to use the computer when they come to visit.

Until second grade, Beth's school use of technology was infrequent, due to broken equipment in her kindergarten classroom, and limited use of the LD resource room computer in first grade. Technology assisted her recognition of letters and words and her understanding of math facts. In second grade Beth began using a computer at school as a tool to write stories that include interesting elements and demonstrated an understanding of the conventions of writing and concepts of number. Beth's mother credits the computer for increasing Beth's self confidence, *"With paper or pencil, she doesn't get into it because it requires fine motor skills. That's her biggest deficit area. The biggest thing with the computer is she's successful at it."*

Epilogue. During the 1993-94 school year, a vision itinerant specialist encouraged Beth to further her computer word processing use. The specialist reports that Beth has displayed improved skills in all areas, and comments, "You would be thrilled by her growth in second grade." A visit to her class revealed that Beth is now producing short essays, using a new computer in the classroom. She also has expanded her use of technology at home with a new computer, a Macintosh® Performa, acquired by her family.

Cathy

Cathy is 4 and lives at home with her mother, one older brother and two younger sisters. She has been diagnosed with cerebral palsy and severe mental retardation. Her condition is complicated by constant nondiscernable seizures for which she takes medication. This condition has left her with a very short attention span which interferes with her activities, both at home and school. Cathy's understanding of causality was increased by a variety of electronic toys, including a music keyboard and Phone Pals. Her mother hopes Cathy will use technology someday to communicate. To explore further technology possibilities, her teacher requested a TTAP

assessment when Cathy was 4. Environmental design techniques were recommended to reduce Cathy's distractibility when using switch-operated toys or a computer. Also beginning communication activities were recommended using a touch tablet and a computer.

At school Cathy's teacher described her approach to using technology as "pre-technology" programming with electronic toys such as the "Touch 'n Talk," although she admits that Cathy is motivated by movement, action, colors, music, and electronic voices from the computer. Cathy had access to electronic toys and an Apple IIe® computer in her classroom. Educational objectives for using technology included attention to task, independence, and receptive language. Her teacher commented, *"She shows something in her eyes...I feel there's hope there. It (technology) will decrease Cathy's need for initial prompting and hand-over-hand assistance, and allow her to become more independent."*

During the course of the study, Cathy initially required assistance in switch pressing 100% of the time to operate a toy or to change the picture or sound in a simple switch program. Although her switch pressing was often random, by the end of the study she was able to make up to 12% of her presses independently during these simple causality activities. This small gain was important considering her short attention span. During the study Cathy also demonstrated an increased ability to maintain eye contact for 30 seconds, and to respond to sensory stimuli in computer software. Her mother credits technology for helping her daughter to become more independent and for the decreased need for prompting during activities.

Epilogue. When Cathy's family moved to another state during the 1993-1994 school year, her mother asked to be placed on the ACTT mailing list. She said the new school staff were interested in technology for Cathy. The mother thought the video summary and the case study was helpful for the school staff to get to know Cathy.

David

Three-year-old David lives at home with his mother and a younger sister. He has a diagnosis of tricuspid atresia, a cardiac condition that resulted in three surgeries and a stroke by age 3. After the stroke, David experienced delays in motor, language, cognitive, and social development.

When David transitioned from an early intervention program into a preschool classroom at age 3, his Birth to Three coordinator and preschool teacher requested a TTAP assessment to help determine his technology needs. Equipment and activities were recommended to enhance his communication skills. Most of David's technology use was at school, since a Nintendo was the only device he had at home. He had access to a variety of equipment at school, including an Apple IIGS computer with an Adaptive Firmware Card, an Echo Speech Synthesizer, a PowerPad®, a

TouchWindow, a Big Red Switch, and a joystick. Software included commercial and public domain programs designed to promote language development and cognitive skills.

Initially, David used the PowerPad, TouchWindow, and a computer with switch input to access the simple causality software programs. David was able to press independently to access the software, but often needed physical interrupts to delay his presses until the program was loaded into the computer. By the end of the study, David had used two additional methods of input, mouse and keyboard. Although he was not altogether accurate with all input methods, he was anxious to explore each one. This showed his versatile physical ability to operate the equipment, as well as his cognitive ability to understand the effects of his own actions with each device. His teacher reported he also had improved in social skills and was tolerating the presence of other children as he worked on the computer. She considered using the case study to secure funding for more equipment; however, David's placement was changed before this occurred.

Epilogue. During the 1993-94 school year David's preschool teacher quit her position to take another teaching assignment. Since his family was not pleased with the new teacher, they moved David into a cross categorical classroom in another school. His new classroom does have an Apple computer, but no peripherals, and very little software at this time. His new teacher says that she needs more training to feel comfortable using a computer.

Eric

Eight-year-old Eric's family includes his parents and four older siblings. He has received special education services since the age of 1, at which time he was diagnosed with mild to moderate cerebral palsy. Eric has impairments which are most apparent with respect to motor and communication skills. When he was 4, his parents and teacher requested a TTAP assessment. Recommendations were made based on equipment and software already available in his classroom. Since Eric demonstrated ability to use keyboard input, a keyguard was recommended to assist his use of keyboard software. Touch tablet input was also recommended for communication activities. The following year another assessment was requested from TTAP and a representative from Don Johnston Developmental Equipment Company to find out what new computer equipment he could use, and to assess whether an augmentative communication device would suit his needs.

Following the second assessment his parents acquired an Apple IIGS computer with an Adaptive Firmware Card through an organization called "The Dream Factory." They had also acquired software, a motorized wheelchair, and various adaptive utensils. His mother received computer training from Macomb Projects in order to set up activities for Eric at home. In his classroom Eric had access to an Apple IIGS computer, an ImageWriter printer and a variety of software programs acquired through a contract with Minnesota Educational Computer Corporation. His teacher had access to a large variety of other software through their school networking system.

Eric used a computer with keyboard input mainly to reinforce academic skills, such as math, spelling, reading and language skills, and to improve fine motor skills.

Eric's computer use was a combination of group and individual activities. During his individual time Eric received one-on-one assistance from his teacher as needed. Since his fine motor skills were limited, she encouraged use of his left index finger by wrapping his hand in an ace bandage to assist with pressing the keys. By the end of the study, Eric had developed his own system of pressing keys on the keyboard using his left thumb, thus eliminating the need for the ace bandage wrap.

During the study Eric's family acquired a Touch Talker™ with the financial assistance of their insurance company. Eric was beginning to use a direct select method of input with the device. He was still in the process of learning the icons and the keyboard of the Touch Talker by the end of the study. Both his family and teacher commented that technology has been beneficial in increasing Eric's problem solving skills, social and emotional behaviors, attention to task, and independence. His mother states, *"I'm hoping that if he can have any kind of independence at all, it would be through technology."*

Epilogue. Because of the health of the teacher, Eric's classroom was discontinued at the end of the 1992-93 school year. He was then moved to a classroom in a special education building within the same school district. He does have access to a computer, but his family is uncertain as to the specifics of his technology use at school since this placement.

Faith

Two-year-old Faith is the youngest child in the study. She transitioned from a Birth to Three program to an early childhood special education program during the study. Her diagnosis is "shaken baby" syndrome, resulting in developmental delays across the cognitive, motor, language, and social domains in addition to visual impairments. Faith lives at home with her mother, step-father, and two younger siblings.

When Faith was 15 months old, her Birth to Three interventionist requested a TTAP assessment. Recommendations were made for activities with a switch and battery-operated toys to foster independence. Following the assessment Faith's family made their own switch from schematics provided by TTAP staff. She used the switch with toys at home.

Faith continued to use this simple technology in her Birth to Three Program to increase her understanding of means-end and increase language. Her teacher also thought that technology might have a therapeutic effect in helping Faith develop physically. At that time she had access to an Apple IIe computer, an Echo Speech Synthesizer, a TouchWindow, various types of switches, adaptive toys, and software programs designed to reinforce early cognitive skills. When Faith transitioned to a special education classroom, she still had the same type of equipment available to

her. She used a switch to change sounds or pictures in simple software programs. Besides cognitive skills, her teacher used technology to help expand communication skills.

During the two-year course of the study, Faith progressed from working one-on-one with her teacher during technology activities to engaging in independent activities using software designed to help increase her understanding of her effect on her environment. However, her teacher found that Faith was more successful in accomplishing the activity objectives when she was with other children or encouraged by an adult in the environment. Her mother thought technology helped to increase Faith's social and emotional interactions with adults and peers.

Epilogue. Faith's family moved to another state after the study observations were completed. According to her mother, she is no longer experiencing seizures. As for technology, her mother reports that Faith has access to a computer in her classroom, but she is uncertain as to specifics about its use with her daughter.

Gary

Seven-year-old Gary likes riding his Big Wheel, going to the park, and playing an electronic keyboard. Along with a diagnosis of right hemi-paresis, he experiences developmental delays in motor skills and expressive language. He lives at home with his parents and two younger siblings. Since Gary's language delay was causing frustration and interference with his interaction with other children, his family was interested in exploring some form of augmentative communication for him.

When Gary was 5, his family requested a TTAP assessment. Computer activities involving speech synthesis and memory building software were recommended to enhance communication and auditory memory skills. TTAP also recommended further assessment for an augmentative communication device. Since Gary already enjoyed a variety of electronic toys at home, computer activities seemed to be a natural transition for him.

Although the computer provided assistance with a variety of skills for him, his parents were also interested in obtaining a portable communication device. With financial assistance from their insurance company the family obtained a Liberator and private speech therapy for Gary. He used his Liberator at home and school and carried it back and forth daily. A direct select method of input was used to access the device. He also had access to an Apple IIe computer in his classroom, and an IBM computer in the computer laboratory. He used a computer to improve his auditory skills and for repetition and practice types of activities. With a combination of daily private speech therapy and weekly speech therapy at school, Gary was able to verbally participate in classroom activities with his Liberator by the end of the study. He made jokes and communicated independently and spontaneously with other children and adults with the Liberator.

Gary's family and teacher have seen many benefits of technology for him. His teacher describes him as more interactive, more confident, and happier at school. His mother credits the Liberator for Gary's increased cognitive and social abilities. *"The Liberator helps show us that he can express himself and use more abstract thinking; more than anyone ever thought that he was capable of."*

Epilogue. At the beginning of the 1993-94 school year, Gary was transitioned into a new classroom based on his age. However, when Gary's new teacher refused to learn to program the Liberator, his family moved to a neighboring school district which would be more understanding of his needs.

Group II

When the study began, the seven children in Group II had been using technology applications from 3 to 8 years, since they originally participated in ACTT sites. This means that they received intervention activities using the ACTT early childhood technology curriculum from ACTT team members or site team members, and that teachers and families were offered training on technology applications. During the study, none of the children were placed in ACTT sites since they had moved out of preschool settings and into the educational system.

Hugh

Hugh, an 8-year-old boy diagnosed with hydrocephalus and cerebral palsy, lives at home with his parents, an older brother, and a younger sister. He began using technology when he was 4, with simple switch and adaptive keyboard activities to enhance cognitive and communication skills.

Hugh had a variety of equipment available to him at home, acquired through a grant written by his parents. Equipment included an Apple IIGS computer with an Adaptive Firmware Card, an Echo Speech Synthesizer, Unicorn Expanded Keyboard, several kinds of switches, and software programs. His classroom for Trainable Mentally Handicapped students had identical hardware as well as some additional adaptive devices.

During the study, Hugh made two significant gains. One was the emergence of functional use of the word "go," while the other was use of appropriate switch presses to activate a series of loop tapes. During the study, Hugh's teacher and speech therapist devised a system of communication using a switch-activated tape recorder with messages recorded on continuous loop tapes. Hugh's teacher found that he often held his left arm against the switch thereby continuously activating his tapes at the beginning of the study. By the end of the study, she said he only did that when he wanted to signal for attention. Hugh was observed using his communication system in

the community on a class field trip. His teacher took him to an ice cream store in a shopping mall where he ordered an ice cream cone by pressing the switch to activate a loop tape.

Epilogue. During the 1993-94 school year, Hugh changed teachers for part of the day, although the teacher who has been using technology has remained with him. The teacher and his mother have expressed frustration with the slow speed of the Apple IIGS computer they are using. However they both indicate that Hugh now communicates better with a switch and his tape recorder than when he started. He continues to use this technology in his community.

James

James, an only child who lives at home with his parents, is 13 years old. Since his diagnosis of spastic cerebral palsy, he first was served in a Birth to Three program, then a preschool program, and then was mainstreamed into regular education with varying resources. James was introduced to technology at age 4 and continued to use it in his educational placements.

During his preschool years James used a computer to help increase various skills, including problem solving and other areas of cognition, communication, fine motor, and social skills. James was adept at using a switch or small touch tablet to direct a robot's movement in his classroom during an exploratory or problem solving activity. He gained fine motor skills and representational abilities through keyboard use with play computer activities on a make-believe cardboard model computer and disk drive, and talking word processing programs on a real computer. ACTT loaned a computer to the school for James to use when he left the preschool program. As he moved from preschool into kindergarten and early elementary grades, he began using a computer to write. During summer sessions with ACTT staff and his parents, James learned to enter words and sentences into the computer. It was a slow process, but he was patient and determined. At this time he continued to work on scanning skills through switch use, since ACTT staff believed that switch input might be more efficient for him as his academic work progressed.

Unfortunately during the middle elementary years his technology use was not continued on a consistent basis as had been the case when he was younger. The staff at James' school had changed, and he was assigned a program assistant who did much of the school work for him. However, ACTT staff continued to lend the family technology support through participation in IEP staffings, phone consultations, and software loans.

James changed placements during the study through promotion from seventh to eighth grade. Besides the motorized wheelchair that he uses for mobility, James has technology available at home and school. He uses an Apple IIe computer, a printer, an Echo Speech Synthesizer, a Big Red Switch, and a voice-activated telephone at home. The use of **Talking Textwriter,** a word processing program which combines speech output and large type display, allowed him to do some homework on the computer with his family's assistance. A public service organization in his

community raised funds to purchase a Macintosh LC II computer, a StyleWriter printer, a Big Red Switch, Echo Speech Synthesizer, and a Ke:nx® interface for him at school. This newer technology provides a faster and more powerful tool to assist James in his schoolwork.

When the study began James used only a calculator and a tape recorder. After the Macintosh computer was acquired for James it took some time before it became a tool he could begin to use independently. Initially when school staff used a computer with James, they would enter words into the program for him, instead of allowing him to enter words himself, either through keyboard or switch use. While James had acquired the technology he needed, without adequate training, school staff were not able to adapt the software to meet his needs. With help, his program assistant was eventually able to customize some of his homework assignments for switch use. At the end of the study James was beginning to use a word processing program, **ClarisWorks**, with a Big Red Switch and Ke:nx to answer test questions.

Although James' technology story has been one of many struggles, he still sees a computer as an important part of his life, an area in which he has experienced success and has gained some self confidence. He commented that he would like to make computer technology his career choice upon completing his public school experiences.

Epilogue. As a result of staff training and equipment support, James is beginning to use a word processor more consistently and is becoming more independent. He has a new program assistant and new teacher. Both participated in ACTT training during the summer of 1993. The school acquired **Co:Writer**, a word prediction program, so that James can enter words into the computer more quickly. During a recent visit, James was writing his journal on his computer by pressing letters on the Unicorn Expanded Keyboard to enter words.

Kenny

Kenny is a 7-year-old whose diagnosis is cerebral palsy (spastic diplegia). He lives at home with his parents and an older brother. When he was introduced to a computer and switch software during a home visit provided by the Birth to Three program, his parents became interested in finding out whether technology could help him with fine motor skills. Simple causality programs were used with the keyboard and an Apple computer. In preschool technology use continued with similar simple keyboard programs and the Muppet Learning Keyboard, a type of touch tablet. Activities focused on fine motor skills, cognition, and social interaction. During kindergarten Kenny's parents once again became concerned about his poor fine motor skills, and

Kenny was enrolled in a regular classroom with support services from a learning disabilities resource teacher.

Kenny changed placements during the study through promotion from first to second grade. He has some technology available at home including an electric typewriter, a Nintendo that he uses with a joystick, electronic games, and an electronic keyboard. Kenny had an electric typewriter, calculator, Apple IIe computer, Echo Speech Synthesizer, and printer available at school. The software programs Kenny used were intended to reinforce math and reading skills.

Kenny was using only a calculator and the typewriter for math problems at the beginning of the study. By the end of the study, he used a computer in his classroom and LD resource room to develop math skills, visual-motor coordination, and improve the legibility of his written materials.

Epilogue. After field observations ended, the research team was contacted by Kenny's physical therapist and invited to revisit his classroom. She explained that he had made progress with word processing and the research team would be interested in seeing the changes. During the visit Kenny was delighted to demonstrate how he used **AppleWorks** on the Apple IIGS computer to type in his spelling words. Kenny now receives services in his classroom rather than in resource room, since his regular education teacher has a special education background.

Lynn

Lynn is a 10-year-old girl with a diagnosis of severe mental retardation. She is an only child and lives in a group home affiliated with a private special education school for individuals with severe developmental disabilities. Lynn visits her home on weekends and during school vacations. She began using technology in preschool at the age of 3. A switch and battery-operated toys were used initially to establish causality concepts. Later simple switch-operated software was used at a computer to develop further cognition skills and to increase communication. After leaving preschool, staff changed so Lynn's use of technology was inconsistent. At age 8, Lynn used a switch to access computer software to improve eye-hand coordination, visual attending, tracking, and to increase communication. Lynn has several channels for expressive language including word approximations, manual sign approximations, a communication book, and gesturing. Staff used technology as motivation for Lynn to use all of her expressive abilities in a total communication program.

Lynn was placed in a self-contained classroom labeled "Severe-Profound", remaining in this placement throughout the study. Although Lynn's mother expressed an interest in obtaining a computer for Lynn, only electronic toys were used at home. However, in school Lynn used technology in both speech therapy and with a paraprofessional tutor. Equipment available in Lynn's school included an Apple IIe computer, Big Red Switch, Echo Speech Synthesizer,

PowerPad, Adaptive Firmware Card, and Unicorn Expanded Keyboard. Software Lynn used included programs to increase attention span, communication, and categorization skills.

One of Lynn's IEP goals for using technology was to enhance compliant behavior and appropriate behavior. Her speech therapist reports that Lynn's behavior has improved and that technology has a positive influence on her. Her mother and tutor think that the computer has also helped improve independence, cognition, and communication. Her tutor comments that technology *"is another mode of information. It increases the things she can do. It is a fun way of learning rather than at her desk."*

Epilogue. Lynn's mother and classroom teacher admit that the computer needs to be used on a daily basis to benefit Lynn. However, inadequate equipment in her classroom remains a barrier to achieving this goal.

Nathan and Mark

Nathan and Mark are identical 11-year-old twins who live at home with their parents, and older sister. Both boys have cerebral palsy and severe developmental delays. Mark is diagnosed with hydrocephalus and is legally blind. Nathan and Mark were unique to the study because they remained in the same placement, a self-contained Severe-Profound classroom, with the same teacher for 8 years, although locations changed three times.

Both boys began to use switch-operated toys and computer programs with switch input when they were 3. Activities were designed to promote cognition and communication skills. Although both Nathan and Mark seemed to enjoy technology activities, Mark was more vocally expressive about his enjoyment, laughing often when he made silly or strange noises come from a computer. Mark progressed from using one switch to change a sound or picture to making choices of different sounds with two switches.

Communication was the focus of many early technology activities for both boys. Nathan selected the toy he wanted by pressing a picture on the Muppet Learning Keys. He also chose what portion of a song, such as "Wheels on the Bus," he wanted to hear by pressing one of five pictures on the PowerPad. Besides selecting sounds, Mark chose between "eat" and "drink" with his switch presses during snack time. He also felt tactile overlays on the PowerPad to select portions of a song.

One of the boys' favorite programs was **Master Blaster**, a switch program designed for two players. Each boy had to wait, watch or listen for the appropriate moment, then press their switch. The activity provided a sense of competition and achievement they might not otherwise experience.

Nathan and Mark had a variety of assistive technologies available at home and school. Equipment at home, purchased by the family, included an Apple IIe computer with Adaptive

Firmware Card, an Echo Speech Synthesizer, homemade tread switches, switch-activated battery toys, and a variety of software. Classroom equipment included an Apple IIe computer with an Adaptive Firmware Card, an Echo Speech Synthesizer, a Wolf Communication Device, a large tread switch, Muppet Learning Keys, a TouchWindow, and a variety of software programs.

At the beginning of the study, the classroom computer was broken and was not repaired for almost a year. The teacher borrowed a computer from the building principal and was able to continue with technology activities during the second semester of observations. Nathan used the Wolf communication device for a few months in the 1990-1991 school year. However, since he could not operate it independently, its use as a dedicated speech device was discontinued at the beginning of the 1992-1993 school year. Mark uses the Wolf to request changes in positions and music for entertainment.

At the end of the study, Nathan and Mark continued to indicate choices for play activities with the Muppet Learning Keys and the software program, **Exploratory Play**. This is the same program they had used years before in preschool. Nathan continued using the computer to communicate simple choices. Mark could also play independently using simple switch-operated software.

Epilogue. Nathan and Mark remained in the same classroom with the same teacher for their eleventh year. Computer activities continue with the same computer, peripherals, and software they had used over the years. During periodic visits to the twins' classroom ACTT staff note both boys have retained skills for using a switch and simple software from year to year, despite time away from a computer during summer vacations and long gaps without computer use at school due to broken equipment.

Paul

Paul is a 7-year-old with a diagnosis of cerebral palsy, mental retardation, and mild von Willebrand's disease. His family consists of his parents and one older brother. Paul lives in a group home affiliated with a special education school for individuals with severe developmental disabilities and visits his family at home on weekends and during school vacations. Paul began to receive technology intervention services when he was 9 months old interacting with switch-activated toys and a tape recorder. Activities were conducted by an ACTT staff member and a local Birth to Three child development specialist. His family was very interested in technology and made a mercury switch for Paul to use at home. Besides switches and toys, a computer was brought on occasional home visits to begin to introduce another tool. Understanding causality, increased attending, and communication were the main goals during technology activities. At 3 years, Paul continued to use technology in a classroom labeled "Severe-Profound." Simple switch and computer activities were continued focusing on cognitive and communication goals. At 5 he

was playing a complex, computer-controlled train game that required cooperation with another child to move an electric train around a track.

Paul's placement during the study was a self-contained classroom labeled "Severe-Profound." At home he had a wheelchair, mercury switch, and some adaptive utensils. Equipment at school included an Apple IIe computer with an Adaptive Firmware Card, a Franklin Ace 1000 computer, a Wolf Communication Device, a variety of switches, Echo Speech Synthesizer, switch input box, joystick, and a variety of software.

At the beginning of the study, Paul's parents requested that he use a Wolf with the hope that it would provide a means of communication. However, use of the Wolf was discontinued during the study because Paul demonstrated little interest in using it. He did not visually attend to the overlay which contained only words, no pictures. His parents did not feel the Wolf provided the auditory or visual feedback needed to hold his attention. Since he seemed to prefer a computer, his speech therapist plans to continue using that technology for language, motor, and cognitive development. However she is planning to implement a more traditional approach to communication, by using a language board with concrete objects as stimuli.

Both the school staff and his mother have seen benefits from Paul's use of technology. The staff saw improvements in visual attending, motor skills, and motivation. In addition his mother finds that computer use improves his self concept in such a way that he feels "good about himself." She comments, *"He's probably happier when he's using them (computers)."* Her hope is that he will be able to communicate through technology. Family and staff continue to evaluate ways technology can help with this goal.

Epilogue. Paul's physical condition has deteriorated, making standing in his standing box difficult. He had surgery on his hips and is in a body cast. Since their initial participation in Project ACTT, Paul's parents have appreciated the work of Macomb Projects and have expressed desire to be a part of any future projects. As a result, Paul is a participant in an art technology project. He uses **KidPix**, a graphics software program, and enjoys creating his own artwork by moving his hand across the TouchWindow.

Results and Discussion

Hi Grandma
I can rit you sum numbrs. I wil see you in 3 weeks.
I love you.
goodbi
Beth

Beth's writing reflects an emergent literacy approach to writing. While her spelling does not yet meet standard spelling requirements, the communicative intent is perfectly clear. Without the word processing program and computer, she

cannot produce readable written words. It took three years for her public school program to recognize the importance of Beth's need to use technology. Because an itinerant vision specialist recognized the possibilities, she now has a computer available for writing. Assistive technology provides Beth, the only child in Group I who was placed in a mainstreamed setting, with the tools to work with other children. Her ability to use a computer was not a consideration for her placement, but it does function in an assistive capacity. At home when children come to play, Beth shows them how to play the games and other software programs she has on her computer. Her mother's insistence and persistence has been the motivating force for Beth and for her mainstreamed placement. It has not been easy. At one point, her mother laughingly reported that she told Beth, *"We're not quitters -- we're fighters!"* Beth responded, *"You mean we hit people?"* The path is not smooth for families or children. Perhaps humor eases the pain.

Neither is the path smooth for staff members. By and large, school staff are not trained to use the wide range of technology applications that can assist children with severe disabilities. Technology support services and/or resources in the form of appropriate hardware and software are not readily available. Some are not ready to believe or accept that technology tools assist children to use their capabilities and potential. The teacher who dropped out of the study said setting up technology activities "took too much time." Another teacher refused to learn to program a child's Liberator, a dedicated communication device, although it was the child's only means of communicating and he used it well. His family moved to another more accommodating district after the study was completed.

Furthermore, the costs and strategies for funding assistive technology present challenges and barriers as do problems with maintaining and obtaining appropriate, well designed equipment. School staff are unaware of potentially effective applications, do not have time to add one more thing to the school day, do not have easily accessed training opportunities in their schools, and do not have necessary hardware and appropriate software. Moreover, some school staff members do not want to learn to use technology just as some children do not seem to show an interest in using specific applications. Some teachers do not have access to equipment. In one school teachers had to wait their turn to receive purchased equipment. Since it was not the year for one of the teachers in our study, she had no computer in the classroom, although the Group I child in her room had access to computers in a resource room and at home.

However, in spite of the challenges and barriers, both staff and parents reported technology's numerous benefits to children, the most notable being in social and emotional development. The findings of the study are discussed across cases and across Groups I and II in the following sections. Group III verification is included for selected topics. The examples are taken from the complete case studies.[7] Case study summaries were presented in the preceding section.

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[7]Complete case studies on the 14 children in Groups I and II are on file in the Macomb Projects office.

Placement and Transitions

Although technology holds the potential for assisting children to accomplish activities in mainstream settings, by providing the tools needed to write, communicate, and learn, only Beth in Group I and Kenny and James in Group II were in mainstreamed settings. The placements for the remainder of the children in both Groups I and II reflected varying special education classroom arrangements. Every child in both groups received early intervention services in a Birth to Three program before transitioning into other services. Following initial contacts with technology, whether by a TTAP assessment or in an ACTT site, the children in both groups experienced from two to four transitions or promotions, moving from one program to another, from classroom to classroom, or from school to school.

Table 1 gives the ages of the children when they began using assistive technology. The average age when Group I children began technology use was 3.7 years. Two Group I children began using switch operated toys at 1 year of age, while a third began as a 3-year-old. Two began as 4-year-olds, one as a 5-year-old, and the seventh began at 7. Group I children began receiving assistive technology services from 4 months to 4 years prior to the beginning of the study's observations.

Group II children began using assistive technology applications at an average age of 3.2 years. They were part of an EEPCD model project (ACTT) focused on early delivery of technology services operating before public recognition of the importance of technology was reflected in the Technology Related Assistance for Individuals with Disabilities Act of 1988 (P.L. 100-407) and before the assistive technology requirements of IDEA were part of the law. One child began using switch-operated toys at 9 months. Four children began using switches and computer at 3 years. Two of the remaining children began using technology applications at 4 years. The ACTT children began receiving services from 3 to 8 years before the study's observations began.

The transitions, promotions, and changes in placement of the children resulted in interaction with a variety of staff members, some who had a high level of competency in technology applications and others who had little if any training or skills. In several instances, families mentioned staff turnover within a single year as a barrier to their children receiving needed technology services.

From the time the younger children in Group I began receiving services which included assistive technology, the number of transitions they made ranged from one to three. New placement sometimes resulted in the children taking steps backward instead of forward. For example, one child in Group I was transitioned from an early childhood classroom where equipment was plentiful and the sending teacher possessed a high degree of technology knowledge and skills to a classroom with much less equipment and a receiving teacher who expressed her

wish to know more about what to do with technology applications for the child. Even if systematic training and resources were available to the new teacher and her motivation to learn was high (as it seemed to be), it would take some time for her to learn enough to routinely apply the applications used by the sending teacher. The child's learning with technology tools is on hold until the teacher catches up.

Transitions for the Group II children ranged from two to four. Therefore, although the Group II children began using technology in programs which replicated ACTT's curriculum integration philosophy, at the time of the study either their placement had changed or the school staff -- and their ideas about technology use -- had changed. Two children remained with the same teacher for 10 years, from the age of 3. However, their classroom designation changed and the location was moved three times.

Technology Use in Educational Settings

The findings of this study reflect the state of practice rather than the state of the art of technology use in educational settings. Across cases in Groups I and II, the use of assistive technology observed in the children's educational programs varied according to the type of appropriate equipment available, access to the equipment, the amount of time spent on technology applications, and the purpose for technology use.

Generally, technology seemed to be viewed by school staff as an alternative way to develop isolated academic skills, rather than as tools to integrate into daily activities. Overall, technology applications were used as individual activities that were not necessarily developmentally appropriate nor related to the ongoing day to day activities in the classroom or at home. For example, three of the children who depended on dedicated communication devices for oral communication were allowed to use the device only during their time with a speech and language specialist rather than throughout the day to communicate with others.

Staff resistance to the communication devices, intentional or not, was illustrated by making the devices inaccessible to the child (i.e., placing the device on a shelf and leaving it there). However, in defense of staff, the devices were heavy and unwieldy to transport and took time to program. Staff also indicated a level of resistance in comments about the amount of time needed to program or use a device and expressed disagreement as to the need for or appropriateness of a device for a particular child.

All the children in Group I received TTAP technology assessments either at their parents' request (three children) or the schools' request (four children). Whether the recommendations were followed depended upon administrative commitment to ensuring the availability of resources to secure appropriate equipment and software. The staff's willingness and ability to assist the child to

use appropriate applications was also a determining factor. Unfortunately, close coordination between home and school was not evident in Groups I or II during the period of the study, as reported by both families and staff. Moreover, coordination among the staff who worked with a specific child was minimal. Time constraints, large caseloads for specialists, and school scheduling procedures were contributing factors.

Clearly, financial resources to secure equipment and software for the children in Groups I and II were limited in most school districts. Expenditures per year for all instructional materials varied across school settings ranging from above $120 for six of the children, $85 to $119 for seven of the children, and $84 and below for one of the children. The child count of special education students at the beginning of the 1993-1994 school year in the school districts that housed the children in the study ranged from one student in the K-6 district in a non metropolitan county to 950 for a school in a metropolitan county. Financial limitations affected the ability of school districts to provide support personnel in the form of paraprofessionals to assist children in the classroom as well as personnel resources to provide technology assistance for the staff.

Equipment Resources

One of the most obvious findings in both Groups I and II was that obtaining and maintaining equipment presented barriers. In some cases, the equipment in the schools was not necessarily what the child needed. Different placements changed the availability of equipment for the children. Inadequate equipment was not considered a major barrier by Group III respondents, perhaps because assistive technology use enjoyed administrative commitment in all the Group III sites. When these sites began using technology, a financial commitment was made to send selected staff for ACTT training and to secure appropriate equipment. In Hawaii, a loan system in conjunction with libraries is used so parents can check out equipment. No such system was available to Group I and II families.

Equipment was, with the exception of James' site, viewed as a classroom resource in Groups I and II rather than a tool for a particular child. When the child moved to another placement, either through transition or promotion, equipment remained in the classroom resulting in uneven availability of appropriate technology activities unless the equipment was owned by the child's family and traveled back and forth between home and school. This was the practice for the Group I children who used augmentative communication devices. Whether the receiving classroom contained appropriate equipment did not seem to be a placement consideration. Furthermore, there was no guarantee that the equipment would be in working order when the child arrived. Repairs took an inordinately long time.

Equipment at school. When the study began in December of 1991, although all the children in Groups I, II, and III had access to some type of assistive technology devices in their

school placements, the devices were not necessarily operable. For example, computers in two sites were broken and not repaired in spite of teachers' requests. The three children in these two classrooms continued using technology with borrowed equipment. Clearly defined systems and resources for equipment repair were not evidenced.

Over the course of the study, classroom computers ranged from an old Apple II+ to a Macintosh LC II. Peripheral devices used in the sites included a variety of switches, the joystick, the TouchWindow, the PowerPad, the Echo, the Muppet Learning Keys, the Unicorn Expanded Keyboard, and the Adaptive Firmware Card or Ke:nx. Group I classrooms also included electronic toys and switch operated toys while Group II added typewriters, a calculator, and switch input loop tapes. Nine of the Group I and II children had usable devices in their homes.

When the study began, two children in Group II, Mark and Paul, used a dedicated speech device (the Wolf Communication Device) in their classrooms. By the end of the study, only Mark used the Wolf for communication. The Wolf was eliminated for Paul in favor of using real objects for communicative events. According to the staff, using the Wolf demanded more representational skills than Paul demonstrated at that time. His teacher remarked that he "totally ignored" the Wolf, perhaps because it had words, not pictures. His parents commented that it did not have the auditory and visual feedback needed to hold his attention.

During the first year of observations, eight of the 13[8] classrooms contained functioning computers. Three Group I classrooms had Apple IIGS computers; one had an Apple IIe; and one had an IBM. Two Group II classrooms had Apple IIe computers, and one had an Apple IIGS. One classroom shared a computer with another room; two classrooms did not have computers, and two classrooms had computers that were not working. Thirteen of the Group I and II children were able to use computers, if not in their classrooms then in computer laboratories, or in their related service settings (e.g., resource room, speech therapy, etc.). The fourteenth child (Cathy in Group I) did not use a computer until the second year of the study. Rather, she used switches hooked to toys and other devices for all applications.

During the second year of the study, there was a 43% increase in availability of classroom computers. Five of the 14 children changed placements at the end of the 1991-1992 school year, and with these new placements came changes in equipment. In addition, equipment that had not worked during the first year was repaired. During the second year, all classrooms contained a working computer. Four classrooms had Apple IIGS computers; seven had Apple IIes; one had an Apple IIe and an IBM, and one had a Macintosh LC II.

Equipment at home. By and large, children did have access to assistive technology devices at home, although the computers were not always in working order. Five children in

[8]Although there are 14 children in Groups I and II, two of them are in the same classroom. Therefore, the number of classrooms is 13. Group I has seven families but Group II has six families because two children are twins.

Group I and four children in Group II, including the twins, Nathan and Mark, had access to assistive technology in their homes. Financial factors were the primary limitations related to the parents' ability to provide technology support at home for the other five children.

Group I children had three working computers at home during the study but two others were inoperable. Most were older Apple models. Anne had a computer with a variety of useful peripherals purchased with insurance and the proceeds of community fund raising events. Beth's computers were first a second-hand model from her grandfather, then a loan from United Cerebral Palsy, and finally a family purchase of a Macintosh Performa. Eric's home computer was provided through The Dream Factory, a philanthropic agency. David's home housed an unused old Commodore 64 computer his mother had in high school.

Nathan and Mark's parents purchased a computer for them when they were in an early childhood program. Hugh's home computer was acquired through a grant written by the family. James's first home computer was provided through the National Cristina Foundation. Macomb Projects loaned James a speech synthesizer, a switch input box, and various software, including a word processing program. His family was recently notified of a grant award for a new Macintosh, software, and adaptive equipment through the Illinois Assistive Technology Project.

Anne, Gary, and Eric in Group I used relatively expensive augmentative communication devices purchased by their families through insurance and fund raisers. By the end of the study, these devices included two Liberators (Anne and Gary) and one Touch Talker™ (Eric) that moved between home and school. All three children use direct select to access their communication devices. During the study Anne used a Light Talker before she got her Liberator. Two children in Group II, Mark and Paul, used Wolf communication devices at school but not at home.

Software Resources

Supplies of appropriate and effective public domain and commercially published software were available but not plentiful. Some sites had sufficient amounts while others were lacking. In order to demonstrate appreciation for participation in the study, Macomb Projects gave a "Baker's Dozen" package of public domain software to 12 sites and one of the families after they indicated a need for more software.[9] Anne's classroom during the second year of the study was without software until the teacher was given a "Bakers' Dozen" package. During the second year of the study, David's school had little software for his use compared to his previous school which was well stocked with appropriate software because his technology-competent teacher made use of all the resources available to her.

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[9]One of the features of qualitative procedures is, at the end of the study, to leave the participants "better off" than they were when they began (Lincoln & Guba, 1989).

The teachers with the most software at their disposal during the study were the ones who knew about available technical assistance resources and used them for a variety of purposes. These teachers took advantage of the Macomb Projects resources, including training, borrowing software, individual child consultation, and simple equipment repair. Teachers who had little software used what was available whether it was appropriate for meeting individual children's goals or not. One teacher explained that once she booted up a software program, all the children used it all day because it took too much time to change it.

Some software can be used for different purposes, depending upon the ingenuity of the teacher or parent or child. Teacher lists of software indicate that programs were used to meet a variety of objectives. Group I teachers listed 30 different software programs they used to attain cognition objectives including **The New Cause and Effect**, and **Beginning Sounds**. Group II teachers listed 19 programs including **Charlie Brown's ABC's, Stickybear Opposites,** and **Creature Antics**. The same software titles appeared again under listings for motor development, social and emotional development, and communication. Only eight different titles were cited by Group I teachers across the latter three domains (such as, **Fun Fair, Mudman, Exploratory Play**), while Group II teachers listed three new titles under the social and emotional domains **(Adventures of Jimmy Jumpers, Elf's ABC's, and Exploratory Play Wind Up**) and one new title under communication (**My House**).

Software listed by Group I staff to meet motor development goals (which were not cited by families and staff as an area where children made improvements) included 11 titles. Only one of these, **Primary Editor Plus**, is not listed under the cognitive domain. Group II teachers listed 10 titles used for motor development which were also listed under the cognitive domain. Software listed by Group I teachers to meet social and emotional goals (which was cited by families and teachers as the area where children made the greatest improvements) included 13 titles, while Group II reported 14 titles. Software listed by Group I teachers to meet communication goals included eight titles, while Group II listed five titles. Only two of these programs were designed specifically for communication (**Managed Articulation Treatment** and **Talk & Scan**). Other software which can be used for communication seems not to have been used.

None of the sites listed graphics software, which can be accessed through the Adaptive Firmware Card or Ke:nx via switch, mouse, or touch tablets such as the PowerPad and TouchWindow, as meeting educational objectives. Yet, children with severe disabilities can use graphics software such as **Master Touch**[10], **KidPix**, and **EA Kids Art Center**[11]. Moreover,

[10]Designed for the Apple computer line.

[11]Both KidPix and EA Kids Art Center are designed for use on color Macintoshes.

field testing by the Expressive Arts Project for Young Children with Disabilities[12] indicates unusually long attention spans and interest when children have the opportunity to access graphics software and create their own images, whether those images are scribbles or more representational drawings.

Further, other divergent software programs which allow children the opportunity to create their own product or determine their own activity were used primarily by the older children. These included **ClarisWorks** (for James), **Primary Editor Plus** and **Writing to Read**, (for Gary) and **Exploratory Play** (for Nathan). Generally the software listed did not rank high in interactivity, which provides opportunities for children to make choices and control the software. Interactivity also includes allowing for a variety of active areas on the screen, following a path the child chooses. Multimedia programs on CD-ROM were not used.

Logo, which allows a child to operate a robot through space via switch or other input, was not used in any of the 13 classrooms, in spite of its advantages for children with disabilities. A child who has no mobility can experience movement through space by means of the robot, can direct the robot through a maze drawn on the classroom floor, or can manipulate objects in the classroom using the robot. Nathan and Mark, at 4, moved Topo, a child-sized robot[13], through space in their classroom, using a Koala Pad. James, at 4, was skillful in this activity. However, when the three boys entered the primary level, this activity was eliminated.

Of the 54 software titles listed by teachers, nine were designed for drill and practice on a specific skill, such as math or reading. Twenty-one of the programs which can be used with switch input reinforced skills ranging from causality concepts to scanning skills. Twenty-three of the programs required keyboard input, although they could be adapted for switch or touch tablet input through the Adaptive Firmware Card or Ke:nx[14]. Almost half of the keyboard programs listed were various drill and practice programs, while the teachers indicated the others could be used for a variety of skills. Only four programs accepted touch tablet input, either PowerPad, TouchWindow, or the Muppet Learning Keys[15]. These programs were used primarily for developing or reinforcing social and emotional development.

Time Spent on Technology Use

Overall, the amount of time Group I and II children spent using technology tools is surprisingly small if one considers the severity of the disabilities and the potential usefulness of tool

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[12]The Expressive Arts Project for Young Children with Disabilities, directed by Patricia Hutinger, is part of Macomb Projects. The project is funded by the United States Department of Education's Technology, Educational Media, and Materials for Individuals with Disabilities Program. PR #H180D20019.

[13]Topo and other robotic equipment for use with Logo was supplied to the classrooms by Macomb Projects.

[14]Seven of the children used an Adaptive Firmware Card; Ke:nx was used by one child.

[15]Four children used the Muppet Learning Keys and the TouchWindow, while two used the PowerPad.

functions. At school Anne used technology almost 4 hours a week. Gary, who also used a communication device, used technology at school an average of 14 hours a week. The other five children's school technology use ranged from 1/2 hour to 2 1/2 hours per week. Only two children in Group I used technology tools more than 3 hours a week at home. Anne spent an average of 17 hours a week using technology at home, while Eric's weekly home technology use averaged 15 hours. Both used an augmentative communication device, as well as a computer and adaptive peripherals. Of the other five children, two did not use technology at home; the home technology use for the other three ranged from 1 to 2 hours each week.

Of the Group II children, Hugh used technology 3 1/2 hours weekly in school, while James spent 11 hours a week in school use. School technology use ranged between 1/2 hour and 2 1/2 hours for the other children. Only James used technology 4 hours a week at home. Two of the other five children did not use technology at home, while the remaining four used technology between 30 to 40 minutes at home. Neither Group I families nor staff reported using technology applications on a daily basis, whenever it was needed to perform a task, nor did the research team observe such use. However, staff in Group II reported using this strategy. Hugh always had his switches with him to make responses.

While the relatively small amount of time using technology is surprising, if one considers the amount of time required for transportation, feeding, toileting, dressing, physical therapy and other activities and services needed by the children, perhaps it is difficult to find the time to fit technology activities into the day. This is particularly true if, as found in this study, technology applications are used in isolated skill building activities rather than being integrated into the child's daily activities. Other time constraints may be related to equipment portability and ease of use. As one mother noted, it is difficult to lug a heavy communication device and several children to a fair or any other community event.

Individual Educational Plans

One indication of the use of technology in children's education is whether or not it appears in their Individual Educational Plans (IEP). By the spring of 1993, all Group I children but Cathy had assistive technology applications, including computer use, written into their IEPs.

For example, one of Anne's goals was that she "will enhance her education through the use of the computer." Her speech pathologist had two goals. One of them states that "Given an eight overlay configuration, Anne will select the specified icon on request 80-90% of the time." Beth's goals include working on eye-hand coordination and keyboarding skills with the itinerant vision specialist for 1 hour a week. Gary had two IEP goals for using his Liberator: "1) to become acquainted with the vocabulary pictures on the Liberator by pushing the picture requested by his therapist; and 2) to make five requests on his Liberator across his environment."

Each of the children in Group II had technology goals. For example, Hugh was to "increase accuracy and use of loop to loop tapes in various settings and use switches or tapes for functional skills (indicating he has to go to the bathroom)." Mark's technology goal was to "Indicate his needs through the Wolf." James' technology goals included "Increasing independence, and developing computer skills." After data collection ended, James was evaluated by an independent school psychologist whose report was used at an IEP staffing. Since then, his teachers have taken a week of assistive technology training. James is using his equipment more appropriately now, using **ClarisWorks** for a variety of tasks. His teachers are making a more accurate assessment of his classroom performance to insure that he gains content instead of indiscriminately passing him through the grades.

While 10 of the parents in Groups I and II reported no difficulties including specific technology goals written into the IEPs, roadblocks along the way were noted. Three parents in Group I and one in Group II said they had difficulties initially, but by the end of the study the problems had been resolved.

When asked to explain the ways they achieved cooperative relationships with the school districts to ensure placement, related services, or programming for their children, four Group I parents said they had no problems while three noted that they engaged legal assistance and/or an advocate. Three Group II parents reported they had no problems in receiving technology programming for their children, but two parents either retained an outside consultant or an advocate to ensure services for their children, and one mother who insisted on specific services became the advocate.

Objectives for Technology Use

Educational staff planned objectives for technology applications across all three groups. The staff reported objectives which were categorized into the developmental domain areas of cognition, motor, communication, and social and emotional development. Examples of items in each developmental category follow, providing a sample of the learning objectives teachers cited. The lists are not intended to be exhaustive.

Cognitive objectives planned by staff focused on skills such as the development of color, money, weather, and time concepts. Motor objectives planned included developing the skills of finger control, isolating fingers, eye-hand coordination, and keyboarding. Communication objectives included vocabulary development, letter recognition, increasing receptive language, and the association of objects with pictures. Reciprocal communication was not among the communication objectives. Social and emotional objectives focused on enhancing self-concept, independence, social interaction, cooperation, and exploratory play.

School staff for both groups of children tended to use computers and peripheral devices primarily for cognitive purposes rather than development in other domains. Parents, on the other hand, tended to view computer use differently. The parents of younger children used computer applications to develop social and emotional abilities rather than cognition, while parents of older children viewed computer applications for purposes of building social, emotional and cognitive abilities equally.

Staff objectives for technology use. Across all three groups cognition objectives were most frequently cited in staff plans for using computers, peripheral devices and dedicated speech devices. Table 2 summarizes the priority staff across Groups I and II gave to planning for computer and peripheral device use across the developmental domains.

Table 2. Summary of Staff Report of Educational Objectives as Related to Technology Use

	Group I n = 15*					Group II n = 11*				
	Number of Responses	Cognition	Motor Development	Communication	Social-Emotional Development	Number of Responses	Cognition	Motor Development	Communication	Social-Emotional Development
Computer and Peripheral Devices	61	39% n = 24	28% n = 17	13% n = 8	20% n = 12	60	53% n = 32	12% n = 7	12% n = 7	23% n = 14
Dedicated Speech Devices	37	47% n = 17	7% n = 3	39% n = 14	7% n = 3	7	43% n = 3	0%	57% n = 4	0%
Electronic Toys	3	0%	33% n = 1	0%	67% n = 2	0	NA	NA	NA	NA
Switch Input Switch Toys	5	40% n = 2	40% n = 2	0%	20% n = 1	8	50% n = 4	12% n = 1	12% n = 1	26% n = 2
Typewriter	0	NA	NA	NA	NA	3	0%	33% n = 1	67% n = 2	0%
Calculator	0	NA	NA	NA	NA	6	50% n = 3	50% n = 3	0%	0%
Loop Tape	0	NA	NA	NA	NA	4	25% n = 1	0%	25% n = 1	50% n = 2

* n = number of staff who responded

Objectives for computer and peripheral device use reported by Group I staff (n = 15) indicated that the computer was used most often to achieve cognitive goals (39%). This was followed by objectives for motor development (28%), social and emotional development (20%), and communication skills (13%). Group II staff (n = 11) also reported the computer being used

most frequently to achieve cognitive objectives (53%). Unlike Group I, however, social and emotional development came second (23%), followed by motor development (12%) and communication (12%).

A difference between Group I and Group II objectives for using dedicated speech devices is apparent. Group I staff report the primary objective for using dedicated speech devices as cognitive development (47%) followed by communication (39%). Group II staff report the reverse; their primary objective was communication (57%) followed by cognition (43%). Sometimes, the purposes cited by staff are misleading. For example, the teacher who worked with Kenny (Group II) indicated that computer use was planned for cognitive development while the typewriter was used for communication development. When questioned, the teacher said that since Kenny was unable to write legibly with a pencil, and since he had perceptual difficulties in which he reversed numbers and letters, the typewriter was used to complete his math homework. The idea was that the typewriter would facilitate his classroom production and also compensate for the letter and number reversals. The notion of using computer software for this purpose was not addressed, perhaps because the homework was on a sheet of paper with fill-in blanks that would fit into a typewriter.

Across cases a dedicated communication device was likely to be used during language lessons, but less often for day to day communication within the classroom. Teachers interpreted children swiping or pushing their communication devices off their trays as meaning either the children did not like the device itself or the children did not have the necessary prerequisite skills to use the device. Whether the children were frustrated at the limited communication allowed by the device, the difficulty in using it, or the activity for which the device was used was not addressed. When Anne's Liberator was programmed with information she thought was interesting such as her attendance at a wedding, she used it during sharing time. But a special message for a visitor went unheard because the Liberator was on a shelf that day, inaccessible to Anne.

Although one individual indicated that the children were not high enough functioning to carry on interactional communication, the evidence is not clear that this is the case since several other factors influence communicative behavior, including having something interesting to talk about. During observations teachers tended to limit children's communication responses to answering convergent questions related to facts and concepts rather than encouraging communicative, conversational interaction with adults and peers. For one reason or another, including difficulty in programming the devices, complexity of the device, limits on time and choices, developmentally inappropriate assumptions about communication, and the child's physical inability to access the device correctly, the children who needed technology to communicate received less than optimum assistance.

Group I objectives for using electronic toys, such as **Touch & Tell**, targeted social and emotional development (67%) while battery-operated toys operated by a switch were reportedly used for a combination of cognitive (40%) and motor development (40%). James and Kenny (Group II) used calculators equally for cognitive and motor development, according to staff. Hugh's teacher (Group II), reported that using continuous loop tapes with switch input was for social and emotional development while toys with switch input were used for cognitive development. She did not elaborate on criteria for making these discriminations.

Group III staff (n = 19) reported that assistive technologies were used to meet the following educational objectives: cognitive (37%), social and emotional development (31%), motor development (18%), and communication (14%). As with Groups I and II, objectives for cognitive development occur most frequently.

Parent objectives for technology use. Parents' objectives for technology use at home did not parallel staff objectives. Both Group I and II parents used technology most often for social and emotional purposes in contrast to school use for cognition although Group II parents, whose children were older, used technology just as often for cognitive purposes.

The majority of Group I parents said they used computers for social and emotional development. Perhaps this is not surprising because social and emotional behaviors are central to the young child's development and interaction with others. The parents of the three Group I children with dedicated speech devices reported that the devices were used for communication development. Parents with electronic or switch toys said the toys were being used for social and emotional development.

Group II parents reported that computers with peripheral devices were used at home equally for social, emotional, and cognitive development. Typewriters were used for cognitive and communication development. Switch toys were used equally for communication, social, and emotional development. None of the Group II children used dedicated speech devices at home, although the schools allowed the devices to be taken home.

Neither Group I nor Group II parents indicated motor development as an objective for technology use. However Group III parents cited motor development first, followed by communication, cognition, and social and emotional development. The Hawaii families were in Birth to Three programs where one of the major targets is often motor development, which may explain their attention to it.

All in all, the parents tended to demonstrate a clearer idea of the function of communication equipment than the staff. Moreover, parents tended to be more optimistic about their children's use of communication devices. Perhaps teachers are tied so strongly to academic skill development that it is the pervasive factor, taking precedence over communication and other areas of behavior. Or, perhaps the full impact of the child's ability to communicate orally, via an augmentative

communication device, has not yet been felt by the staff involved in this study. One factor may be that they believed cognitive skills were needed during early use in order to understand the operation of the devices; therefore, the software was used for training, not for communication. Another factor may be that the devices were too complicated for the child to use or that the child lacked the physical ability to properly access the device.

Managing Instruction

Differences in strategies used to manage technology instruction among groups were found. Group III staff reported the most comprehensive understanding of the elements of technology planning. The majority of Group III staff responses on management of technology instruction involved the use of assessments to determine the skill levels of the children. Assessment, which is critical to successful use of hardware, peripherals, and software, was not cited by the first two groups as a part of management. However, Groups I and II did cite lack of technology assessment as a barrier.

Group III's responses were more complex and sophisticated in other areas, including staff consultation, individualized adaptations of equipment, individual equipment, home visits, and integration of technology into everyday, functional activities for the children. Since Group III participants were part of ACTT, a model technology replication project, one could argue that replicating the management component of ACTT resulted in more comprehensive and competent management strategies since that was part of the initial training as well as follow up activities.

Group I used one-on-one programming as the major form of instructional management. The 25 Group I responses involved either one-on-one programming (7 responses, 28%) or use of different levels of software for each student (5 responses, 20%), followed by small group instruction and independent use (both with 3 responses, 12% each). The other seven responses were divided among the categories of individualized equipment, exploratory play, small group instruction, and integrating technology with instruction.

Group II staff also reported the use of different levels of software, although one respondent said that all students used the same software programs. Twenty-nine percent (6 responses) of the 21 Group II responses identified management through use of different levels of software, followed by management through classroom scheduling procedures (4 responses, 19%), and integrating technology with instruction (3 responses, 14%) as the most commonly used management procedures. Planning technology activities and one-on-one programming were also mentioned (both with 2 responses, 10% each). Categories of sequential instruction, consistent repetition, and direct instruction followed by practice each received one response.

One-on-one programming for Group II students was reported by teaching staff to be used less often than for Group I students. However, observations revealed that the bulk of Group II's

programming was, indeed, one-on-one. Group technology activities, one place where children with severe physical disabilities have the tools to participate in group games or stories, were the exception rather than the rule.

Effects of Assistive Technology

While the effects of technology over time were intricately related to the nature of the children's school placements and educational experiences, staff and families alike agreed that technology use had positive social and emotional outcomes for the children. This finding was borne out across groups in four different sets of data: detailed case studies of the Group I and II children over time; family and staff judgments on improvements made by children; judgments related to differences between technology and non-technology activities; and evaluation of the benefits of technology. Although staff reported planning technology activities to increase cognitive abilities, they indicated that the greatest positive impact was on social and emotional development.

Child Improvement

School staff and the family members were asked to evaluate the positive effects of assistive technology use over time across eight areas including communication, play activities, functional activities, academics, social interaction, social outcomes, control over the environment, and emotional outcomes. Data on improvement were collected during interviews using a directed item. Participants were asked specifically whether they saw improvements in each of the eight areas during interviews and were encouraged to provide as many comments as they wished to make about each area. Responses were balanced across respondents. No single individual provided an unusually large number of responses. As a group, the parents of all the children in Groups I and II reported improvements in the areas of interest to the study with an emphasis on emotional outcomes. Parental comments tend to be fewer (a total of 77 comments in Group I, 88 in Group II) than staff (a total of 144 comments in Group I and 145 in Group II); however, more staff (15 in Group I and 16 in Group II) responded than parents (7 in Group I and 6 in Group II). Table 3 indicates the number of parent or staff responses in each of the eight categories and the percent of those responses which indicate improvement.

Staff reports on improvement. While the greatest improvement was reported in social and emotional outcomes, and specifically in "emotional outcomes" across families and staff in both Groups I and II, the Group I staff reported improvements in all areas including academics, communication, environmental control, social interactions and social and emotional skills. Group II staff reported improvements in all areas except play and functional activities.

Examples of improved skills were given by staff. A Group I teacher characterized the changes she saw in Cathy as a result of her use of technology. *"She attends to it [the computer] more than other toys. She's become more interactive with all of us. She gives better eye contact. She is more personable, more affectionate."* A Group II teacher explained how technology has

Table 3. Summary of Parent and Staff Report of Skills Improved Through Technology Use

	Parents				Staff			
Skills Areas	Group I n = 6*		Group II n =6*		Group I n = 15*		Group II n =16*	
	Responses	% Indicating Improvement	Responses	% Indicating Improvement	Responses	% Indicating Improvement	Responses	% Indicating Improvement
Communication	6	83% n = 5	7	57% n = 4	11	55% n = 6	12	67% n = 8
Play Activities	4	75% n = 3	4	100% n = 4	5	40% n = 2	7	86% n = 6
Functional Activities	6	50% n = 3	7	57% n = 4	9	44% n = 4	11	55% n = 6
Academics	15	87% n = 13	20	90% n = 18	37	55% n = 20	37	57% n = 21
Social Interaction	6	83% n = 5	6	50% n = 3	10	50% n = 5	11	55% n = 6
Social Outcomes	28	75% n = 21	30	70% n = 21	53	57% n = 30	47	51% n = 24
Control over Environment	6	67% n = 4	7	86% n = 6	9	56% n = 5	10	80% n = 8
Emotional Outcomes	6	83% n = 5	7	100% n = 7	10	90% n = 9	10	80% n = 8
Total Responses	77		88		144		145	

* n = number of parents or staff who responded

helped Lynn improve independence and control of the environment, *"It is another mode of information. It increases the things she can do. It is a fun way of learning."*

Group III staff data supports that of Group I and II, with 56% of the responses saying improvements were made in social and emotional development.

Parent reports of improvement. Overall, the parents' expressions of improved abilities in Groups I and II tended to be higher than comparable staff perceptions of improvement. The Group I staff reported the greatest gains in emotional outcomes compared to the other skill areas while the Group I parents saw the greatest improvement in academics with emotional outcomes equal to improvements in communication skills and social interaction. Group II staff reported that emotional outcomes were equal to the skills the children had developed to control their

environments while the parents saw the greatest improvements in play activities and equal improvements in emotional outcomes.

All of the Group II parents' responses revealed their perception of improvements and changes in emotional outcomes. Eighty-three percent (83%) of the responses of parents of Group I children saw improvements in emotional outcomes as well as all other skill areas, with the exception of functional activities where responses were split 50-50. Similarly, Group II parents reported improvements in all skill areas with the exception of social interactions. Fifty percent (50%) of the responses noted improvements in social interactions and 50% reported no change in this area.

Group II families also reported improved skills in play and to a lesser extent in functional skills. Group III families did not see the magnitude of social and emotional improvements identified by the staff; however, they reported a similar sequence of skill development with equal value given to social and emotional development (37% of the 19 responses) and cognition (37% of the 19 responses). Perhaps the impetus on providing technology activities initially came from the staff, since they were part of a technology replication site. This was not the case in Groups I and II during the study. Although the Group II children started in an ACTT site, by the time the study began, they had moved into other placements.

While all parents reported improvement in some areas, they did not see changes in others. Sometimes, the ability was already present, as in Kenny's case. He communicates well and, as his mother said, *". . . he's always been good at communication."* However Anne's mother indicated that the Liberator *". . . has not facilitated spontaneous communication."*

A Group I mother described the skill improvements displayed by her 4-year-old son, David, *"The main thing is, he is more independent. He is getting along with the other kids a lot better. His behavior is better when he is on the computer..."* Eric's mother said, in talking about improvement in communication, *". . anything that catches his attention will motivate him to function more."*

Comments about children using technology. Staff and parents commented on the attitudes of the children as they used assistive technologies. One Group I teacher gave this description of Beth: *"When she is on the computer, she is very happy and excited because she is able to get simple tasks right."* Another teacher said, *"David likes the computer so we do see more attention to it and smiling. He does have eye contact with the computer. We are trying to get him to be more social at the computer and it seems to be working. He enjoys the computer for play."* A Group II teacher responded, *"They [Mark and Nathan] enjoy it...and on the computer, they can make choices and tell us what they want depending on the program."* A Group II administrator, when talking about James, indicated, *"He's more patient. He is willing to try new things. He is more resourceful I would think."*

The parents were also asked to comment on their children as they used technology. Anne's mother (Group I) said, in describing her daughter, *"Motivated or enthused or happy is [a descriptor], if there's that message in there [in her Liberator] that she really...wants to tell, especially if she comes [to school] and she's got something exciting to tell that she did the night before or...wants to tell some kid 'Happy Birthday.' If it's extremely motivating to her, then you see a definite motivation and wanting to use it [her Liberator]."*

David's mother added, *"The main thing is, he is more independent. He is getting along with the other kids a lot better. His behavior is better when he is on the computer unless he doesn't like the program."*

Mark and Nathan's mother (Group II) described her sons as they used technology in interactive games. She said one son was *"really aggressive and really into 'This is my territory and my switch and I'm going to beat you and that's it.'"* However, she said this of her other son; *"I don't know if I have a description for him. [He] is a mystery in many ways and I think that applies to computers as well."*

Comparison Between Assistive Technology and Non-Technology Activities

Comparing the children's responses as they worked with activities incorporating assistive technologies to activities using conventional instructional approaches was accomplished in observations and in interviews. Parents and staff alike in Groups I and II reported improvements and/or changes with technology instruction as compared to non-technology instruction

Staff reports. Eight Group I staff members said they noticed that children's responses in developmental domains were improved or changed with technology instruction as compared to non-technology instruction in this order: social and emotional skills, cognitive skills, communication skills, and motor skills. Only four (16%) of the 25 responses from Group I staff identified no differences in child responses as they compared the two instructional approaches.

Seventeen responses from nine Group II staff members revealed a similar sequence of improved skills when comparing technology and non technology instruction. They reported that social and emotional skills were greater during technology instruction as were cognitive, communication, and motor skills. However, three (18%) of the responses from Group II staff saw no differences in child responses.

Although staff members reported skill improvements when the children used technology, sometimes their responses when comparing the children's participation in technology activities to non-technology activities were equivocal. Anne's teacher said, *"As far as general visual attention, I think overall it's better, but I can't say with anything else that there's that much difference. It's just whatever...happens to really motivate her."* Beth's teacher said, *"I think she is pretty much the same. The computer is just another [type of] learning material."*

Group II staff responses were generally positive. Hugh's teacher said, *"I think...when Hugh has his technology, he pays attention better, and we're at fault for not providing it for him at all times. I think...during calendar time when he has that switch in front of him and he knows he's going to be doing the ABC's, I can tell that he's paying attention so that he's ready for it."* A Group II administrator said of James, *"If everything is working, I see a more positive boy, a more gratified boy, and a more satisfied person. If everything is not working, he gets a little depressed, a little down."*

Parent reports. When asked to compare their children's responses between technology and non-technology instruction, Group I parents saw improvements or changes in the same order as did Group I staff. They saw improvements in social and emotional skills, cognitive skills, communication skills, and motor skills. Six (9%) of 23 responses indicated improvements in communication skills. Six (9%) of 23 responses indicated no differences in behavior in technology activities as compared to non-technology.

The greatest contrast was produced by the report from Group II parents as they compared technology and non technology activities. They listed the sequence of improvements and changes in this order: cognition, communication, social and emotional, and motor. Every Group II parent viewed her child as exhibiting improvements and positive changes in at least one area. Since these children were older than Group I, parents had lived with them a longer time and perhaps developed a set of confirmed expectations. Moreover, the children had time to develop a more comprehensive repertoire of behavior and more technology competencies.

Parents tended to describe more positive behaviors than those given by the staff when comparing the children's participation in technology and non technology activities. Group I parent comments include the following. Anne's mother said, *"She can be happy doing many things and she likes to work on the computer. That makes her happy . . ."* Beth's mother said, *"Definitely she is happy with it [technology], when it makes the sounds and she gets it right. It's like, 'Yes, I got it right!'...She sits up very straight at the computer, very straight with her head up."*

Group II responses were comparable. The twins' mother said, *"For Nathan, anybody who watches any of his [video] tapes would realize immediately that he giggles; he kicks his feet; he laughs; he enjoys it [technology] from his head to his toes."* She said her other son *"does a lot more vocalizing" as he uses technology."* She added, *"I don't know what kind of stimulation that is, but there's evidently something there that causes him to be a little more verbal."*

Benefits of Assistive Technology

All family members and staff were asked to describe the benefits of assistive technology applications. This was an open-ended request. Comments were recorded, then categorized during analysis. The degree of perceived benefits assigned to developmental domains varied across

respondents. All felt the children received the most benefits in the social and emotional domain, with the exception of Group II parents who reported equal benefits in cognitive and social and emotional development. Table 4 summarizes parent and staff data on the benefits of technology applications.

Table 4. Summary of Parent and Staff Report of Benefits of Technology Use

	Parents			Staff		
Benefits	Group I n = 6* Responses = 15	Group II n = 5* Responses = 20	Group III n = 8* Responses = 16	Group I n = 7* Responses = 33	Group II n = 11* Responses = 51	Group III n = 12* Responses = 31
Cognition	20% n = 3	35% n = 7	19% n = 3	24 n = 8	35% n = 18	26% n = 8
Motor Development	7% n = 1	0%	13% n = 2	3% n = 1	6% n = 3	6% n = 2
Communication	7% n = 1	15% n = 3	25% n = 4	21% n = 7	16% n = 8	23% n = 7
Social/Emotional	66% n = 10	35% n = 7	31% n = 5	49% n = 16	41% n = 21	45% n = 14
Other	0%	15% n = 3	12% n = 2	3% n = 1	2% n = 1	0%

* n = number of parents or staff who responded

Staff. Staff members in all three groups reported technology provided the greatest benefits in the development of social and emotional behaviors, not an easy goal to achieve. This is congruent with staff reports of improvement across developmental categories. Social and emotional benefits were followed in descending order by reports of increased cognitive development, communication development, and motor development.

Of the 33 responses given by the seven Group I staff, technology was identified as being most beneficial in the area of social and emotional development (49%), followed by cognitive development (24%), communication development (21%), motor development (3%), and "other" (3%) in descending order. One staff member felt she had personally benefited from her use of assistive technologies with children, and cited this use as a benefit, accounting for the "other" category.

The benefits of technology applications reported in the 51 responses from the 11 staff for Group II children followed Group I's sequence with the children experiencing the most benefits in the area of social and emotional development (41%), cognitive development (35%), communication development (16%), and motor development (6%).

Twelve Group III staff gave 31 responses which were similar to those of Group II. Forty-five percent (45%) listed the greatest benefit as social and emotional development. This was followed by cognitive development (26%), communication development (23%), and motor development (6%).

One Group I teacher looked to the future as she said, *"It could make a difference in her participation in an occupation...If it all goes the way I like, she will use it to enhance her education and progress in her school work for tests, math, [and] spelling...It will enhance simple work skills. It allows more communication. It helps with visual attention, and it helps with her visual tracking."* Another Group I teacher said technology has increased the child's skills in many ways. She explained, *"She attends to it [the computer] more than other toys. She's become more interactive with all of us. She gives better eye contact. She is more personable, more affectionate. Is this tied into the computer? It's hard to say, but it has happened at the same time."*

A Group II administrator anticipated the same long-term types of benefits as did the Group I teacher. He said, *"I think that due to his handicapping conditions, he will always require some assistance, but I think introducing him to computers early...is going to help him for the job market. He ought to be able to function somewhere in our society on a limited basis with computers. That's my goal."* A Group II teacher said technology had benefited the children and the classroom staff. She said, *"...They make decisions now for themselves, and we don't have to do everything for them. [Technology] also [provides] entertainment."*

Parents. The parents saw technology as benefiting their children in the same order as did staff. Out of 15 responses, the six Group I parents reported technology provided the greatest benefits in the development of social and emotional skills (66%), followed by cognition (20%). Consistent with their responses to their perception of improvement, the five Group II parents, who gave 20 responses, reported that their children showed equal improvements in the areas of social and emotional development (35%) and cognition (35%), followed by communication development (15%). Benefits in motor development were not reported. Eight Group III parents indicated in their 16 responses that major skill improvement were social and emotional (31%), followed by communication (25%), cognition (19%), and motor development (13%), although they reported that motor development was their number one objective.

A Group I mother felt the whole family had benefited from her daughter's use of technology for communication. She said, *"I feel we see major benefits for our daughter and our family in decreased frustration."* She added, *"I feel that Anne is seeing herself as a person with worth as opposed to her being a frustrated baby. I think she sees herself as a little girl. Prior to that, she was such a frustrated person and I think people thought of her just as an infant because she cried so much because she was so frustrated."* Beth's mother saw benefits in her child's

increased attention. She said, *"I think [she attends to the computer] because she can do it. It's that satisfaction of accomplishment that she doesn't need anyone else to sit there with her to do it."*

Hugh's mother (Group II) discussed one way her son used a switch-activated tape recorder, to participate in classroom activities. She said, *"He's proud of himself when he has the 'Pledge of Allegiance' tape on. I think he is happier."* A Group II mother reported on anticipated future benefits as did some Group I staff and parents. She said, *"If he can learn how to use the computer, then he can get his ideas out just as quickly as everyone else. Then he won't fall behind [his classmates]."* Another mother saw benefits for the whole family as did a Group I mother. She explained, *"It's [technology] given us more family time together, or at least more quality time with the...boys themselves."*

Challenges and Barriers

Across groups, when talking about challenges and barriers, with few exceptions, concerns fell into the same areas listed when the problems encountered when children began to use technology were discussed. The areas of concern include financial resources, training, equipment constraints, software problems, time constraints, collaborative issues, communication issues, and characteristics of children. In all cases, financial resources and training concerns received the greatest emphasis.

During both formal and informal interviews, the participants in the study continued to discuss challenges and barriers to children's use of technology as well as critical components of technology use. Information on challenges was elicited when staff and families were asked to describe the challenges they faced in the classrooms or related service areas as they managed technology applications. A similar strategy was used in eliciting comments on barriers.

Financial Resources

The staff and families for all groups cited financial challenges and barriers in terms of insufficiencies among problems they encountered when their children begin to use technology applications. Financial problems included 1) inadequate support services, 2) inadequate funding, 3) inadequate classroom equipment, and 4) inadequate classroom staffing. Parents remarked negatively about staff turnover which resulted in inconsistent services. While turnover may be due to "burn out," it may also reflect inadequate resources in the form of low salaries and insufficient personnel. One Group I teacher said, *"It would be great if we could get a one-on-one aide [to work with Cathy] but the money is just not there..."* For a year Cathy's mother tried unsuccessfully to get financial assistance to purchase a home computer.

Finances also limited classroom media and materials used with assistive technologies. In both groups, staff opinions of adequacy of equipment and materials were split. Half of Group I staff respondents reported they felt their equipment and materials were adequate; the other half disagreed, indicating that the equipment and materials were inadequate for their purposes. Similarly, nearly half (44%) of the Group II staff respondents felt their equipment and materials were adequate, while another 44% said they were inadequate, and others responded that they just didn't know at this point. Hugh's teacher said, *"I'm lucky to have what I have but I don't know if it is adequate for all of the children."*

Four parents (two each in Groups I and II) said the lack of computers in their homes presented a problem. Funding was unavailable. Difficulties in dealing with public service agencies to obtain assistive technology was also indicated as a barrier by families in both groups. A Group I mother said after her child's TTAP assessment, *"It [the assessment] made me feel like there was a way to open some doors for her to be able to accomplish this [communication]. I guess I was real excited about where it [technology] could lead and what she could accomplish...[I felt] If I got enough papers [information], I possibly could get help getting a computer [for home use]. I tried all last year through organizations with no success."*

Training Concerns

Staff technology training is uneven as children progress through school. In the best of situations, ongoing training and support for staff and families is built into the system. However, for those in the study, this was not the case. Staff and family technology competency varied across groups as did the amount and intensity of staff and family training. Lack of training was demonstrated when technology applications were used as individual activities that were not necessarily developmentally appropriate nor related to the ongoing day to day activities in the classroom or at home. Generally, technology seemed to be viewed by school staff as an alternative way to develop isolated skills, rather than as providing tools to integrate into day to day activities.

Four of the teachers who first began using technology with Group I children developed technology skills in ACTT training. When Group II children began using technology, prior to the passage of the Technology-Related Assistance for Individuals with Disabilities Act of 1988, they were in classrooms where teachers had extensive training from ACTT and, for a period of time coinciding with external funding, extensive resource support from Macomb Projects. However, as the children moved from one placement to another, teachers' competence in technology use was not assured and varied randomly.

When the Group III sites agreed to replicate ACTT, one or more members of their staff came to Macomb for at least one week's intensive training or two ACTT staff members traveled to

train staff. In most cases, the staff interviewed during this study were second or third generation staff who had been trained by those who had trained earlier in Macomb.

Staff training. Groups I and II staff reported receiving both formal and informal technology training. Formal training included college courses, Macomb Projects' training, technology workshops, technology consultations, school inservice programs, and training from manufacturers particularly for staff working with children with dedicated speech devices. Informal instruction included training from a professional peer on the staff or a family member, employment experience outside the school setting, and self-instruction.

Group III staff received technology training in much the same way as did the staff for Groups I and II. Most reported receiving their training procedures through conferences, seminars, and inservices, followed by Project ACTT training, personal experience, and a professional peer provided training. Other modes of training for Group III staff included computer courses, self-instruction, and training from vendors.

In spite of past training opportunities and experiences, staff noted the lack of personal training and technology support services as a barrier. Training issues centered on 1) difficulties in program planning with adaptive equipment, 2) lack of training and information, 3) lack of communication between staff members, and 4) inadequate assessments. Variation in staff technology skills during the study were apparent as were their views on the need for further training.

Cathy's (Group I) teacher added this about her technology training, *"I wish someone with more training could work with her."* A competent Group II teacher felt her training had been helpful, but she saw the need for more training. She said, *"If we didn't have the training that we did, we'd still be at ground [zero]. It has helped us all a lot. Just think how long it's taken me to figure out how to hook the Ablenet [switch] into different places; just to actually get used to the way the arm [a universal switch mount] works and what you can hook it on and what you can't; what switches work and which don't. It's mostly a lot of trial and error, but I wouldn't have even known what's out there without some of the training. I still need more when it comes to ways to incorporate it [technology] into the curriculum, but it [the previous training] has helped with that."* Another Group II teacher had this perspective on the importance of technology training, *"The more confident we are with the computer and the more we know, the more the child will get out of it."*

Overall, Group II staff indicated greater competency in technology applications. During the second year, competency data on 13 Group I and 11 Group II staff, according to their own report, showed that they can all operate a computer, but only 53% of Group I and 65% of Group II can assemble the equipment. Only 19% of Group I staff and 39% of Group II know how to connect and operate peripherals, yet 71% of the children across the two groups use the Echo (a voice synthesizer) which must be connected to the computer. Fifty per cent of Group I and 60% of

Group II staff indicated that they could design a computer environment, while 54% of Group I and 78% of Group II were competent in designing computer intervention sessions. Only 8% of Group I and 34% of Group II indicated that they were able to develop procedures to involve families.

Parent training. Parental responses reflected similar competencies and types of training experiences including computer courses, training from manufacturers for those parents with children using dedicated speech devices, Macomb Projects' training, self-instruction, and employment experiences. Parents of three Group I children (Faith, David, and Cathy) and one Group II child (Mindy) said they had no technology training. The majority of the parents received their training from the staff of their child's service center. These parents received training in equal proportions from college courses, personal experience, conferences and seminars, and self-instruction. Other training came from equipment vendors.

Anne's mother (Group I), who participated twice in week-long ACTT computer training and who sees assistive technology as a benefit to her daughter, took the initiative and arranged for private training on her child's dedicated speech device. She explained,*"I'm not real comfortable...I'm afraid I'm going to plug something in and we're not going to get it out, so she's [a representative from the manufacturer] coming to my house...for a private training and if Anne's teachers would like to come [they are welcome]...I told her 'I don't care if I have to pay the $75 or whatever myself to get you here, but I need some more training.'"* Anne's speech therapist and other school personnel attended both Liberator workshops her mother organized.

Equipment Concerns

Equipment constraints included 1) cumbersome equipment, 2) inadequate design, 3) malfunctioning equipment, 4) difficulties in obtaining repair, and 5) incompatibility. Both staff and families cited incompatible home and school computer systems as a barrier to technology use.

Staff and families alike noted the difficulty of working with malfunctioning, inappropriate, or ill designed adaptive equipment whether it was computers, wheel chairs, or other devices. The computers and related equipment in four classrooms malfunctioned at one time or another during the study. Since the schools did not have a technology repair system nor a trouble shooter to determine the cause of the malfunctions, the equipment was unavailable for use.

Twenty-two percent (22%, n = 9) of the 42 Group I and II staff responses mentioned malfunctioning equipment as a challenge when they used technology. A Group II teacher commented on other equipment problems, saying, *"The computer was gone for a considerable amount of time because nobody knew what was wrong with it. So we had it several different places before we knew [what was wrong]...It was a connector inside of the Mother Board that had gone bad and then also the AFC [Adaptive Firmware Card] had bad chips. So the two of them together, nobody could figure out what it was."*

Beth's mother cited an additional barrier concerning second-hand equipment. She said, *"We have just tons of programs but we don't know exactly what they are for and how to use them. I think that's kind of a problem when you buy a second-hand computer with all the stuff that comes with it...Starting new with a brand new one, it's just a little different than buying it second-hand."*

The design of equipment was a major concern to staff and parents who were involved with dedicated speech devices. Mounts for various devices are not compatible so each time a communication device changes, a new mount must be purchased, adding considerably to costs.

In commenting on design, a Group II teacher said, *"Look at the time it takes to get everything together, and every time it's a new setting...you have to move everything. I have to really concentrate on these wires to see if they're hooked up to the right tape recorder [for the child's communication system]."* When Gary's (Group I) mother said that her son's device was heavy (e.g., 20 pounds) and difficult to take along on family outings, she provides a clue for designers. When Anne's mother opened her daughter's Liberator during an observation to illustrate that it did not seal tightly she also showed how her daughter's saliva had eroded the surface of the "Toolbox." The mother said too, *"...if I was redesigning [it], I would change [the] on and off switch to another place, because if [her daughter] pushes down [on the surface of the device]...she can't always just hit [the correct place]...She [moves her hand] slowly and she'll turn the speech off."* Anne's speech therapist described other problems with the device. He said, *"You get that Toolbox flipping open and closed a few times and then the hinges start to fall off. You switch overlays a few times and then the little plastic clip[s] that hold that all together...loosen more, so they're slipping around."* He added, *"It's very big. It's very bulky, therefore it's difficult to always have it where you need it."*

Three parents (one in Group I and two in Group II) stated that the equipment was either cumbersome or caused difficulties in social situations when taken into community settings. A mother whose child who used a Liberator for augmentative communication summed it up,*"The Liberator can be a pain. It weighs 20 pounds first of all. The other day we went through a little carnival and he was so excited and I know he would have been pushing 'up' and 'down' but who wants to drag a device around on your arm in the sun when you have three kids?...When we have a family gathering, there seems to be so many little children and they can't leave it alone...I feel awkward having to tell somebody else's children 'Please, don't touch this.'"*

Parents expressed concern about inadequate support services offered by manufacturers of dedicated speech devices and unreliable vendors who did not furnish timely repairs. The parents dealing with unreliable vendors tended to make their own equipment adjustments and repairs rather than wait for services which would leave their children without equipment.

Problems with Software

Software that was difficult to use was also a concern to families and staff. Anne's teacher recognized that the response time of the program Anne used to match numbers by making sequential switch presses was too fast for her to activate appropriately. Even when the parameters were set to the slowest level, the program was still too fast.

During the observations it became apparent that often the type of software used was poorly suited to children's needs. For example, a child with significant fine motor limitations was supposed to use a mathematics program in which he had to type an answer within 5 seconds of the response cue. The teacher knew the program was too fast and that it fatigued the child to use it, but she did not know how to change the parameters of the program. This not only reflects a problem with software, but a need for teacher consultation, training, and follow-up.

A Group II mother related a problem she had with obtaining appropriate software beyond the cause and effect level, although recommendations had been made for software to extend their abilities. She said, *"We're still using things [software] that [they] used when [they] were 5 years old. . . it does get old after a while, doing nothing but* ***Master Blaster*** *and the music. So after a while I'm not sure the boys lost interest as much as we did because I felt like we weren't doing that much for them.."* Her comment points to the need for providing continuing systematic follow up, materials, and support to families.

Time Constraints

Another challenge reported by staff across Groups I and II were time constraints within the classroom schedule. In one case, the teacher mentioned that the child's uncontrolled seizure condition added to the time needed for planning and programming assistive technology applications. Other teachers noted that limited time resulted in decreased technology use because they felt it took too long to boot and/or change their Apple II series software programs. For example, a Group II teacher, who had previously identified her need for more training, commented, *"I feel like they need to make things [software] that boot up quicker so the person doesn't have to sit there. It's so lengthy for [the child] to sit through that, and it just seems like it doesn't always work. You can boot a program up and something will interfere with it and then you have to boot it up again and they have to sit there twice through it."* The teacher did not realize that if the software had been "booted up" before the child came to the computer, it would have been ready when the child was ready. If she were trained or had ongoing access to a technology consultant, her procedures would probably change.

Sometimes complaints reflect the capability of the equipment being used. A Group I teacher said, *"...I find that [changing programs] the most frustrating thing, in fact a lot of times, I don't use the computer as much as I should or would because it takes so much time to switch from one*

program to another program..." A Group II teacher expressed similar feelings when she said, *"It's not real often that I bring in a new program. There's probably about four or five different ones over there now and they [the students] pretty much know what to do and I don't change them that often because it's too big of a pain. Everyone pretty much uses the same programs."* Newer, faster computers with memory for storing numerous programs on the hard drive would alleviate many of these teachers' time concerns and provide children easy access to a variety of programs. However, limited school budgets often prohibit new technology purchases.

Critical Components of Technology Use

When asked to identify critical components of technology use across Groups I and II all respondents mentioned financial and training concerns. However, staff and parents differed in their identification of the most critical components to successful technology use. Table 5 summarizes these responses. Staff focused on the importance of the child's prerequisite skills and appropriate instructional programming, while parents in both groups identified appropriate equipment as being most critical. As part of carrying out their role, teachers have been trained to determine prerequisite skills and to figure out what children need to learn. Therefore, their concern about prerequisite skills is understandable; however, staff also acknowledge the importance of appropriate instructional activities.

Table 5. Summary of Parent and Staff Report of Critical Components for Technology Use

	Parents		Staff	
	Group I n = 6* Responses = 20	Group II n = 6* Responses = 30	Group I n = 9* Responses = 47	Group II n = 9* Responses = 44
Development of Prerequisite Skills	15% n = 3	20% n = 6	40% n = 19	30% n = 13
Appropriate Instructional Program	0%	10% n = 3	26% n = 12	27% = 12
Additional/Appropriate Equipment	30% n = 6	50% n = 15	9% n = 4	25% n = 11
Adequate Classroom Staffing	10% n = 2	3% n = 1	11% n = 5	4% n = 2
Adequate Training/Information	15% n = 3	8% n = 2	6% n = 3	11% n = 5
Other (e.g. Adequate Funding, Access to Equipment, Technology/Developmental Assessment)	30% n = 6	9% n = 3	8% n = 4	3% n = 1

* n = number of parents and staff who responded

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Staff responses to interview questions tended to focus on the inadequacies of the child more than on the inappropriateness of a technology device or activity. For example, one Group I teacher explained that one of her students needed to learn *"to isolate her fingers...She needs to increase her attention span. Right now she needs one-on-one assistance."*

A Group II teacher said of Kenny, *"His visual-motor [skills] need to improve. Also, he needs assistance and probably needs to learn more about the computer as far as word processing which he will get next year."* When discussing appropriate technology programming, this teacher said, *"I was using it [the computer] quite a bit for a while. I'd say every other day for about a month, and I thought, 'Well, this will kind of give him a better attitude and it won't be so hard for him to write the numbers. He can just use the computer for them.' Then he would sit over looking out the window and say 'Can I quit? I'm bored.' So, now if it's just once in a while, then it's neat and he thinks it's something special."* This implication, that technology operates as a reward, or "something special," denies its use as a functional tool in a variety of situations.

One can ask whether fault lies with the child (as the teacher implies) or whether the activity, software, and input method are inappropriate, or whether the teaching goal is developmentally appropriate. A Group I Learning Disabilities Resource teacher was on the right track when she expressed this concern about a child's technology adaptations; *"I'm not sure that it's [technology] helping with what I'm working on because I'm not sure if that's the right [software] program for that."* If an activity or application or hardware is not working, inappropriate adaptations or activities may have been selected, and changes need to be made. A technology evaluation will help determine appropriate adaptations and activities.

Parent concerns were more likely to focus on characteristics of the educational environment and inadequacies of equipment rather than inadequacies of the children and activities. For example, only 15% of Group I parent responses and 20% of Group II parent responses indicated that they felt their children needed to develop prerequisite skills before they could use technology applications. On the other hand, 30% of Group I parents and 50% of Group II parents responses indicated that they felt the classrooms needed additional and/or appropriate equipment. In contrast, only 9% of Group I staff responses indicated the need for additional equipment. Twenty-five per cent (25%) of Group II staff responses identified additional equipment as critical.

Parents also mentioned technology accessibility when discussing critical components. A Group I mother expressed this condition succinctly, saying that technology has to be *"accessible for Beth on a daily basis, home and school. It's not going to work if we have it at home, but she can't use one [a computer] at school. The availability [of a computer] has to be there; not in the library; not Monday, Wednesday, Fridays; [but] consistently day in and day out."* While this was not occurring in the child's school placement during the spring of 1993, follow up in the fall of 1994 found that the itinerant vision teacher had taken the steps necessary for Beth to write using

word processing software. Samples of her writing are used at the beginning of the sections of this chapter.

Lack of Collaboration

Deficiencies were found in the collaborative process not only among colleagues at school but also between parents and the school staff. The lack of communication among staff members, particularly in Group I, decreases the possibility of team planning and integrated educational activities. While Swartz (1993) emphasized the necessity for collaborative planning to support the individual needs of children, collaboration was the exception rather than the rule. When a Group I speech therapist was asked to describe her collaboration with the teachers, she replied that she sees them *"only in the hall"* because of her schedule. Time and schedule seemed to present major barriers to opportunities for collaboration and consultation regarding children's educational programs, including aspects of technology. About half of the 15 Group I staff participating reported they worked in a collaborative way to manage assistive technology applications at school; however, 11 (64%) of the 17 Group II staff said they worked in collaboration with school colleagues.

Collaboration between home and school was less than that among educational personnel. Staff in both groups mentioned differing expectations for technology applications between home and school as a barrier. This was a concern for parents too. In the spring of 1993, Beth's mother noted that she was dissatisfied with her child's school services because of the discrepancy between her expectations for technology use and those of the staff. She said, *"I don't think it's [the school's perspective on technology use] up where mine is. I still don't think they see the total possibilities...We're not on the same wave length yet, but I think they're getting there."* Beth's mother is one who brought in an advocate to ensure that her child would be served well in a mainstream setting.

Only three of the 15 Group I and six of the 17 Group II staff and parent responses indicated that the parents worked in collaboration with the school staff on assistive technology objectives. This collaborative process may have been hampered by the lack of technology available in the homes of some Group I and Group II children; however, the parents were not even involved in making decisions about the day to day or long term content and management of technology use for their children. Neither were they asked for input regarding the child's characteristics such as preferences, interests, and tolerance level.

Communication Between Home and School

Communication and collaboration represent two different kinds of behavior. While communication can be one-way or two-way, collaboration requires interaction among family

members and school staff. Although there appeared to be deficiencies in developing collaborative relationships between the schools and homes, the majority of parents reported the communication between home and school concerning the progress of their children was good. Only one parent, whose daughter lived in a group home and was not at home on a daily basis, reported that she did not receive direct communication from her child's school.

Methods of communication consisted of daily notebooks, weekly notebooks, on-site visits either daily or occasionally, phone calls, quarterly reports, and IEP conferences. Gary's mother reported that her son's Liberator enhanced home and school communication besides developing the child's self-esteem. She said, *"He also likes to report the home news and the school news [with the Liberator]. He's proud to tell me what happened at school and I think he's happy at school to tell them what's going on at home. It's been really nice."*

Characteristics of the Children

Medical conditions and characteristics of the children were sometimes cited as challenges or barriers. A Group I teacher commented on the effect the child's medical condition had on her use of technology; *"Some days she attends a lot better than others. I think that depends on her seizures."* Field observations confirm the teacher's report of the variability of Anne's participation in classroom activities. Just prior to the tenth observation, the child experienced a seizure and fell asleep. During the semester that she had seizures, Anne's attention[16] to technology activities varied considerably.

Parent responses in both Groups I and II cited child behavior problems such as noncompliance, distractibility, and lack of responsibility while using the expensive dedicated speech devices. Two other child-related concerns were reported by parents. One concern related to the parent expecting less than the child was capable of doing. The other related to the child's refusal to use a device that made her look different than the other children.

In the first situation, although her son *did* use technology applications with some degree of skill in his early childhood program, a mother underestimated his ability. She said,*"I don't know if David could understand any formal training, not yet. He's too young."*

Conformity to group standards was reflected in the children's responses to technology use. For example, Anne's mother indicated that her daughter refused to press a switch with her head because no other child in her classroom pressed a switch that way.

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[16]Attention was operationally defined as eye contact with the device or monitor.

Implications and Recommendations

What I Can't See

I can't see friendship, but I know it is there
when my friends play with me.
I can't see curiosity, but I know it is there
when people wonder why I'm in a wheelchair.
I can't see generosity, but I know it is there
when people share with me.
I can't see kindness, but I know it is there
when people help me with things I can't do.
James

James, the oldest child in Group II, wrote this poem on a computer when he was 11. Now 14, he is using a word processing program with several assistive features that help him write with greater ease. When James writes poetry on his computer the ACTT technology team members who have worked with him since he was 4 are proud, as are his parents! But James and his parents have continually faced many problems and small successes to ensure his progress. Very likely, his problems are not completely unique. James has cerebral palsy with severe physical involvement, visual impairment, and a past history of many surgeries. He is able to communicate orally, although his speech is often slow and slurred. James has been in a mainstreamed setting in a small rural school since first grade. Because of this placement, sometimes he did not receive necessary special education services such as resource placement, speech, occupational or physical therapy. Administrative policies and the parents' wishes were and continue to be sometimes at odds. As teachers and aides changed, the emphasis on computer use changed, influenced by their technology abilities, knowledge, and interests.

One day, when he was 10, we heard James, sitting in his wheel chair, say to us in his slow and halting speech, *"On Fridays, I go down to the handicapped room and help them. . . learn computers. . . they need it."* The equipment he uses has changed from an Apple II system to a Macintosh LC with input from a touch tablet or switch through Ke:nx. When he was 5, the National Cristina Foundation gave him an Apple II to use at home, through the efforts of Macomb Projects whose staff have also provided continuous consultation, assessment, and training to his family and school staff over the years. At various times a Macomb Projects staff member has also been included in staffings and IEP development. Ensuring that equipment is used and maintained has required ongoing attention. James' experiences with other children (who acknowledge him and "watch out" for him), with his teachers (who have passed him from one grade to another in spite of his inability to read at grade level and to acquire the content his peers acquired), with his aide (who thought she was helping him by doing his work for him), and with the many professionals who work with him provide a pattern to weave his experience into the whole tapestry of technology use.

Very likely James' and his family's successes and problems are similar to the experiences of others. Minimally, even though technology was written into his IEP by the time observations ended, James' experiences point to the need for continuing technology assessment, expanding

applications to meet the requirements of growth and development, ongoing staff and family resource support and training, ongoing staff supervision, and administrative support.

Although rural, midwestern communities provide the settings for these case studies, the strength of the findings across cases would suggest that other children with significant disabilities and their families across the country might make similar gains and face similar barriers. Technology is not a frill for these children, rather it represents useful tools and ways to learn. Staff and families agreed that children made progress. Observations over time revealed positive changes even though services were often inconsistent as children moved through school.

One of the most powerful and encouraging findings of the entire study is that children with severe disabilities do, indeed, evidence positive social and emotional changes over time when they use the tools of assistive technology. This finding confirms the claims of many professionals and families who have been reporting for some time that when children use switches, electronic toys, computers, the accompanying peripherals, software, and electronic communication devices, the effects are positive.

Benefits related to improvement in cognition and communication were also found. Across the case studies, the children were able to do things at the end of the study that they had been unable to do when they began using technology applications although changes in behavior came very slowly for some. Slow changes were expected since the children who participated in this study were selected because they were significantly disabled and needed technology tools to function in their everyday settings. The results support the contention that assistive technology provides the tools for children who are not able to access the people, objects, and events of their world to do some things independently.

When children with multiple disabilities successfully move a robot around a room or hear a communication device say "eat" expressing their own communicative intent audibly and clearly for the first time, their faces light up. When a child communicates with others and makes himself understood using an augmentative communication device, the child, the parents, and early intervention staff are understandably pleased. These events occurred with some of the children studied during their early years. But whether the positive early responses and benefits were maintained and expanded depended upon families, children and staff successfully negotiating a series of winding paths through a number of barriers in the educational system.

The study describes what happened to children who began their journey through the educational system with a national technology model for young children. The children in Groups I and II had moved from one placement to another. Disappointingly, as they grew older and left ACTT services or TTAP follow-ups, the technology services they received were often inadequate and/or inappropriate although some reference to technology may have been made in their IEPs. Comprehensive technology plans for each child were not developed nor sent forward when

placements changed although all but one of the children had technology goals written into their IEPs. Ongoing technology re-assessment was not a part of children's plans unless some outside agency was involved. When placements changed, the receiving staff may or may not have had technology competencies. Equipment and software varied in kind, availability, and maintenance. Procedures to ensure smooth transitions into new placements did not include technology considerations related to teacher expertise or equipment and software availability. These factors suggest that concerns, issues, skills and knowledge related to technology use by children with multiple disabilities do not play a role when schools determine placements. If all staff were well trained and equipment was readily available, placement considerations would not be as great a barrier nor would they sometimes be a hindrance for children. So although beginning activities may have resulted in benefits, the effects of new placements sometimes marked a step backwards or a holding pattern for children.

Equipment does not follow the child as s/he moves through the educational system unless, like the communication devices that travel between home and school, it belongs to the family. Neither is the availability of appropriate equipment a consideration for placement in the child's receiving program. Furthermore, the equipment may be broken and remain so for some time. Participating in effective activities at one point in a child's school life does not ir sure that these adaptations and activities will continue and grow along with the child.

Discrepancies between families and staff regarding expectancies and objectives for technology use were found. Combined with the findings that collaboration between families and staff was minimal, the discrepancies are not surprising. Staff turnover is an expected part of the educational systems. Caseloads are sometimes staggering. Families have lived with their children far longer and know them better than the staff. Unfortunately, in spite of its importance, family input is not a major contributing factor to planning technology activities for children. Since families have a major investment in the children's futures, and because the law is clear, they must be part of the assessment teams and the staff who plan for effective adaptations and activities.

Educational Use of Assistive Technology

Across case studies the use of assistive technology observed in the children's educational programs varied according to the type and appropriateness of equipment and software available, access to the equipment, the amount of time spent on technology applications, and the purpose for technology use. Goal #5 of the Illinois Goals, adopted by the Illinois State Board of Education (1993) states that "All Illinois public school students will attend schools which use technology as a resource to support student learning and improve operational efficiency" (ISBE, p. 2). The Illinois schools who participated in the study were struggling to meet this goal. When the study concluded,

all but 1 of the 14 children had at least one generally stated technology goal that was addressed in some fashion in the IEP.

Using technology tools did not insure inclusion in settings with non-disabled peers. Only one child in Group I and two in Group II were placed in a mainstream setting in spite of the current emphasis on inclusion. Beth's placement was because of her mother's insistence and persistence, not because the school initiated the placement. Because the children remained in segregated classrooms they did not have access to the world of other children. Opportunities were limited to continue the initial growth made when they began using switches, toys, and computer adaptations. If the focus of daily classroom activities remains only on feeding, toileting, dressing, transportation, and therapy, then not only is time on technology limited, but staff focus on the importance of daily use of technology tools is diluted.

As a rule, the staff who worked with the children during the study did not have a clear vision of the potential uses of computers, communication devices, and related equipment which can allow children to function in regular classrooms. Rather, staff viewed computer applications and communication devices as a way to teach isolated skills instead of integrating the tool functions of equipment and software into the children's daily lives. While a narrow view of technology uses may be expected when teachers begin to use applications with children, a broader view is needed.

The findings point to the need for massive ongoing training efforts with follow-up, demonstration, modeling activities, and consultation more readily available. Without training, assistive technology use is haphazard, not focused on a particular goal. Merely using technology and hoping that something good happens is not enough. Training needs to include content related to what adaptations work, why they work, how they work, and why they work with one child and not another. Further, technology is rapidly changing. Computers that were purchased 5 years ago can be used but in a sense, are obsolete. Staff who were trained 10 years ago, even 5 years ago, need to keep their knowledge and abilities current so they can use new equipment and fresh ideas for integration. Continuing training is likely to ensure that staff know about easier, more effective adaptations available for even the older computers. The ISBE Policy Statement (1993) notes that "even if access [to technology] is provided, the potential of technology to transform education and improve student learning cannot be realized if teachers do not know how to use it and/or it is grafted onto the existing curriculum and the traditional classroom routine" (p. 8).

Given the strength of the results showing improvement in the children's social and emotional growth and development, together with the results showing less than optimal educational use of technology devices and applications, one wonders what would have happened to the children if their placements had been rich in equipment, software, and well-trained, knowledgeable staff. The Illinois Policy Statement (1993) noted that meaningful access to technology is necessary. Children need available equipment, easily accessed during the school day, that they can

use when they need it. This is not possible when the computers are in another room or when communication devices are on the shelf.

Communication devices are, for one reason or another, sometimes not used for communication purposes. Although 10 of the 14 children in the study could not communicate orally, the educational planning objectives made by staff for technology activities primarily targeted cognitive purposes. Objectives to foster meaningful communication were in the minority. Gary made the most gains in communication via his Liberator. He was the only child in the study who had language therapy at school as well as a private therapist secured through insurance funding. He is also the child whose teacher refused to learn to program the Liberator.

Parents tended to demonstrate a clearer idea of the function of communication equipment than the staff. Since the technology competency level of the staff was uneven, perhaps they did not realize the full impact of the child's ability to communicate orally, via an augmentative communication device. Or, perhaps the equipment was too complex, communication software was not available, or activities which targeted isolated skill areas were ineffective. These results again point to the need for staff development related to technology applications. Apparently staff did not realize that communication devices can be interfaced with computers to allow access and integration of the available applications.

The power of the new technologies provides ways to do new and different things but when first introduced, they are likely to be used to do traditional things such as drill and practice. Too often this was what we found to be the case in the study. Powerful equipment that could communicate ideas in sentences with a "macro" was being used to answer "yes" or "no" questions. The Illinois Policy Statement (1993) acknowledges this tendency, noting that Callister and Dunne (1992) pointed out that using computers in the same manner as more traditional technologies like chalkboards, paper, and pencil has been a frequent practice. Rather than using the new technologies to explore new ideas, teachers who have not been trained to teach with and through technology have limited its use to rote tasks like drill and practice, or for remedial work (p. 9). Much of the software used by children in the study was for drill and practice purposes.

Finally, administrative awareness, attention and support for the technology needs of children with multiple disabilities is needed in order to solve the attending problems and provide the ensuing benefits. School systems need to engage staff and families in long range planning for obtaining and maintaining equipment, software, classroom management, technology assessment, continuous training of staff and families, and curriculum planning.

Equipment and Software

Even though equipment, including hardware and peripherals, and software may be housed in a classroom, whether it was used regularly was quite another consideration. Equipment was not always accessible nor suitable for the children. Sometimes it was too complex for the child's developmental level or physical abilities. For example, the beginning software for one communication device was said to be for training to use the device, not for communication itself. Educationally it makes more sense to provide software that, from the beginning, shows the young child the power of communication. Finding the "right" pictures on a communication board when the language therapist requests it is quite different from telling another person, "We got a puppy last night." The devices themselves suffered from design problems, a factor noted by staff and families alike.

For the most part, the computers in use were several generations away from current state of the art computers. None of the classrooms had CD-ROM drives or multimedia software. With the exception of James and the promised new computer, it will be difficult to upgrade the computers and devices in the schools unless creative means of funding are found or funds generally used for another purpose (i.e., to purchase traditional materials such as textbooks that are outdated when they are published) are funneled into equipment and software. A policy of upgrading equipment should be a part of every school district's plans, together with budget planning, supported collaboratively by *all* the state agencies that are involved education including those serving children with significant disabilities.

The software available in the schools represented relatively traditional and linear approaches to learning. Software was not always plentiful nor developmentally appropriate. None of the children in the study used drawing and painting software programs. Only two of the older children used software that would allow them to create their own products and those were primarily word processors. Drill and practice programs prevailed. Access to a wider variety of software together with training in the use and evaluation of software is needed.

If children with multiple and severe disabilities are to make optimal positive changes as a result of interacting with the tools of technology, then all the staff who work with them must be trained to use the tools flexibly and creatively, to manage appropriate technology instruction, to establish appropriate learning objectives, and to meet the changing needs of the children. Without this component, families meet too many barriers that are discouraging and that hinder their progress. Furthermore, the children's growth is hampered.

Children who have significant physical disabilities together with intact cognitive functions can use technology adaptations for a number of tasks, including drawing and writing. They can accomplish some of the same things that typical children accomplish if the appropriate tools are

available. Beth's writing and James' poem attest to this. Children who demonstrate both damaged physical abilities and damaged cognitive functions can use computers, switches, and other technologies to make choices and to interact with software. Even when children cannot use an adaptation independently, interaction and a form of communication is often elicited. Adaptations for children with widely varying disabilities and characteristics are now possible, with new possibilities marketed with increasing frequency. However, they will not be used if staff and families are not trained to use them or if funds are unavailable for purchase.

Recommendations

A paradigm shift among staff and administrators is needed if the schools are to make use of the potential of technology for children with disabilities. Rather than using the available technologies for traditional purposes, new avenues must be explored. New concepts of appropriate adaptations and activities for children with disabilities are needed as well as resources to support the staff who plan those activities. Before this occurs, it is likely that carrying out massive awareness and training efforts which will reach both the organizational level and the classroom level is essential. These activities can be carried out by parent and professional organizations, institutions of higher education, public schools, and agencies if they have an underlying foundation in technology applications. Unfortunately, at the present time, some organizations have yet to recognize the importance of technology. Family organizations nationwide seem to underscore the importance of technology applications to a greater extent, and with greater understanding, than some professional educational organizations. Administrative emphasis on and support of effective ongoing staff development as well as providing adequate funding for equipment and materials are necessary if children are to benefit.

Technology applications must be integrated into children's daily lives rather than being treated as a means of developing isolated academic skills. Teaching plans, strategies and technology management must be changed in order to provide full use of various applications. Changes such as these are unlikely unless massive staff development activities and changes in preservice education are undertaken. Software that assists teachers, families, and children integrate technology use is scarce. Too much software targets drill and practice, encouraging the development of isolated skills.

Since the technologies described in this study are powerful enough to produce positive effects in social, emotional, cognitive, and communicative development for children with severe and multiple disabilities, other children with similar needs should have consistent access to computers, alternative input and output devices, and appropriate software in their educational

programs. Even small gains are important and improve the quality of life for children and their families.

Technology plans for children, developed by a team of professionals and the families, updated at regular intervals, must be in place for each child with disabilities and written into the IEPs. Initial plans should evolve from a team-based technology assessment. Resources to implement the assessment recommendations must be available. When children move from place to place, a policy procedure must be in place so that equipment either moves with them or that similar equipment is available in the receiving setting. Further, receiving staff should be competent in technology use and have access to ongoing staff development activities.

Computers and other assistive technology equipment need to be in the classroom with the child, not in a resource room down the hall. In addition to individual activities, group activities need to be planned so all the children in the classroom use the equipment. The targeted child will probably benefit even more when s/he is included in group activities.

A concerted effort to provide a system and procedures to support collaborative efforts among staff and families is essential, not only during early childhood but as children progress through school. Planning, although important, is not enough. Action is needed. Discrepancies between the families' purposes for technology use and the school staff's purposes should be minimal. Families should have opportunities to provide input into their children's use of technology whether or not they are able to provide similar technology at home. A staff and family team approach is needed. A team approach to assessment and planning as well as implementing adaptations and activities is necessary because no one person can be expected to know how to assess factors such as positioning, placement, and adaptations and then suggest and carry out strategies for implementation. Family input into the entire process is necessary if applications are to succeed over time.

Families need assistance in acquiring information about purchasing computers, communication devices, their accompanying peripherals and software, and training. Assistance might come from the school district, the special education cooperative, or a public service agency. However, the pathways for securing such assistance should be clear and available to all.

Inclusion plans made by school systems need to recognize the importance of the assistive technology tools used by children with multiple and severe disabilities and include both the equipment, software, and staff training. Schools need to go beyond planning, insuring that procedures to serve these children are in place. While children with mild to moderate disabilities can use technology applications in their lives, children with severe disabilities *must* use them to speak, to write, and to accomplish other tasks. Staff responsibilities to assist in providing services must be accompanied by resources to provide needed technology training on an ongoing basis.

Policies at the district and state level that provide opportunities for systematic staff and family development in technology applications, ranging from simple applications such as adapting toys for switch use to more complex content such as designing adaptations for word processing are needed. Ongoing technology training at the preservice and inservice level is needed for the entire team of professionals who work, or intend to work, with children with disabilities.This training should include case study approaches similar to the case approach used in business and law schools to provide learners with concrete examples, issues, and problems. Faculty and training teams must be trained to use the approach.Videotapes of children, families and staff using equipment and discussing the applications in use, and benefits and barriers should be part of this training. Hands-on activities should be a major part of training events.

Administrators need to endorse and allow training time directly related to technology during school time or staff should be compensated for spending out of school time. If administrative support is not evident, non-technology teachers are likely to attend other training because of their fear of technology, their attitude that technology is not needed for the children they teach, or that they cannot take time to learn one more thing.

A system for staff and family support in using applications and trouble shooting should be part of the school system. Support resources might include ongoing formal and informal training, written materials and articles which are easily available, networking groups or "user" groups for families and staff locally, and access to a telecommunication link to national resources. A technology specialist and troubleshooter on staff would be helpful, especially if they were knowledgeable about the needs of children with disabilities.

School districts and agencies that serve children with disabilities must have a system for maintaining and repairing equipment in a timely fashion. Collaborative strategies that call for combining resources among several districts to obtain repairs is one way to accomplish this. Repair services call for knowledgeable equipment service persons and available parts. Sharing these resources with families for home equipment repair while at the same time determining reasonable costs for repair services would alleviate some of the families' concerns.

School districts and agencies need to be aware that technology changes therefore a purchase is not forever but must be updated. Budgets need to include upgrading equipment. Newer equipment is faster and more powerful and is likely to alleviate the time constraints referred to by teachers. A policy should be in place *and in use* for updating equipment and software. This may mean setting up a lending library. If agencies collaborate, the resource could be used by families as well as staff. Perhaps joining forces with the state library system would enhance this effort. Families should be permitted to take equipment used by children home during the summer and at other times.

Designers of equipment need to consider their products carefully to determine whether or not the devices can be used easily by child audiences, although the market may be small. A survey of parents of young children with disabilities who use technology is needed, not a survey of adult consumers. Needs differ.

Software designers need to develop interactive software targeted on problem solving and integrating technology into daily life rather than depending on drill and practice software related to academic skills. Software should be designed so that it can be used by children with and without disabilities alike. Software should be accessible to children with disabilities.

Companies that provide health insurance for families of children with disabilities need to expand their views of allowable services, providing funds for technology tools needed so the children can participate in activities normally unavailable to them. Together with equipment, insurance should fund therapies such as speech therapy when a child acquires an augmentative communication device or occupational therapy when, for example, a child needs to develop a reliable movement to control input.

Need for Further Research

While this study was only funded for a two-year duration, we were able to follow children who began to use technology early in their lives over a longer period of time since videotapes and records from their first technology uses were available, as was epilogue information, after formal observations ceased. While longitudinal studies are expensive to mount, such research is needed. Case studies that follow children with similar disabilities who have access to varying amounts of technology use are needed so they can be compared with the cases in the present study. Further comparisons among children using similar devices would be helpful in determining effective educational strategies. We do not know whether the children in this study had access to more equipment than children in other parts of the country although members of the Expert Panel suggested this might be so. Neither do we know whether other children have access to a cadre of better trained teachers as they move through school. Do children who start using technology tools later in life make as many gains as the children in this study? Studying the impact of technology on children over time when they have consistent and constant access to trained staff and families, optimum equipment and software, and consistent, appropriate applications would be instructive to the field.

The present study's qualitative approach provided a means to study a unique group of children with differing disabilities over time. Further studies which use the protocols we used would be useful so that other researchers could then build on this work and provide a broader base of procedural activities based on naturalistic inquiry.

While it is difficult to mount research which examines attitudes toward technology use, we believe studies which examine the attitudes of school and agency staff as compared to families are needed. Variables for study include the nature of attitudes and their impact in relation to technology available, applications used, technology competency level, characteristics of children's disabilities, and child progress. Of particular interest are questions related to the effects of administrative policies and support on staff and children. Exploring the nature of differences between parents and staff expectancies, perceptions, and activities related to assistive technology ranging from birth to 3 programs through secondary school would provide useful information related to educational planning and procedures.

Further research is needed on characteristics of developmentally appropriate and useful computer and augmentative communication applications for children from 2 (or earlier) to 8. Studying the impact of new technologies and new multimedia software on the learning of children with disabilities will likely provide useful information regarding child, family, and staff outcomes. Studies are needed that target communication equipment, software, necessary conditions for their use, and the effectiveness of their uses with children. If outcomes are to be communication with other children and adults, then appropriate strategies to do so during each day on well designed equipment must be studied. Developing software that addresses integration of content and skills in meaningful ways, then determing the effects of the software on children with varying disabilities, would assist families, educators, and children.

Determining the nature of effective classroom management and educational planning strategies across various settings is needed. As inclusion settings become more prevalent, research will be needed on the most effective management strategies for incorporating children with severe disabilities and their assistive technologies into the classroom, as well as the technology's impact on children with and without disabilities. Additionally, the need to determine appropriate systems and strategies for ongoing technology support for staff and families in rural and urban areas is apparent.

Determining the most effective strategies for training staff and families is needed, taking into account differing levels of technology expertise, attitudes regarding the usefulness of technology, learning styles and other relevant variables. The use of technologies, including videotape and other distance learning modes, in the teaching and learning strategies need further research. The outcomes of staff and family development activities on children need further study.

Summary

In conclusion, assistive technologies represent both a symbolic and a real way of providing families and professionals with opportunities, equipment, and materials to encourage children's

social and emotional development, autonomy, and independent behavior, in effect to "head learned helplessness off at the pass" as children grow older. But can we say that these benefits actually occur in "real life" with real children and families? The answer is "yes," but it depends on the resources of the educational program, belief in technology benefits, the technology competence of his or her educational staff, the child, and the interest, resources and persistence of families. Technology outcomes are limited when a staff member says, *"There are some days that the computer programs have not worked since the Speech and Language Pathologist is not always sure what she is doing with the computer."*

However, if some of the barriers in the educational system are surmounted, then families should not have to expend so much of their energies ensuring that their children receive the benefits of technology. In this case, children benefit and so will society. As one teacher in the study said, *"There's a big, major change with independence from the beginning till now. Before someone had to sit with him at all times . . . Now I can turn him loose on several programs and he can do it without assistance from someone."*

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Appendix A

Descriptions of Group III Sites

Group III sites were selected randomly from the 57 ACTT replication sites across the United States and in Canada. Six sites in four states and Canada were chosen and are described below.

In 1989, the state of Hawaii made a statewide commitment to integrate technology into birth to three programs through the purchase of equipment and software, training of staff, and administrative support. Of the 12 birth to three programs in the state, two were selected for interviews Parent-Child Development Center and Leeward Infant and Toddler Development Center. Both sites received initial ACTT training in 1990. Madeline Chun, Program Specialist for Computer Support from the State of Hawaii Health Department Zero-to-Three Hawaii Project and coordinator of Hawaii's state-wide replication of ACTT's Birth to Three curriculum, was also interviewed for her state-level perspective on assistive technology use.

The Parent-Child Development Center in Waianea, Hawaii, is a private, non-profit agency that serves over 40 children with disabilities including Down Syndrome and cerebral palsy. Four staff members received technology training.

Leeward Infant and Toddler Development Center in Pearl City, Hawaii, serves children who are physically disabled and/or mildly to severely developmentally delayed. Five staff members serve the program's 60 students.

The Society for Manitobans with Disabilities is a private agency in Canada serving the needs of preschool aged children with disabilities between the ages of birth to 6. Both center-based and community-based programs are offered through the site. The center has 47 staff to serve 170 children. The Society for Manitobans with Disabilities received initial ACTT training in 1987.

Signal Centers in Chattanooga, Tennessee, operates a private, comprehensive education and therapy program for preschoolers, ages 6 months to 6 years with cognitive and/or physical delays. The center's 20 staff members serve 90 children and received initial ACTT training in 1988.

The Quincy School for the Handicapped in Quincy, Illinois is a private day school profoundly developmentally disabled children. The birth to three early intervention program provides nonresidential services to children who are accepted on referral from the special education district from the area in which the child resides. The school has six staff members serving 20 children. The Quincy School for the Handicapped received initial ACTT training in 1987.

The **Educational Service Center** in Corpus Christi, Texas acts as a liaison between the Texas Educational Agency and the local education districts. Technology training and assistance is provided to facilitate compliance with state and federal guidelines. Children between ages birth to 22 are served in an 11 county area. The Educational Service Center received initial ACTT training in 1990.

Appendix B

Parent/Teacher Questions about Technology Use: Group I and II: Part I

1. How is she/he using technology at school? In what ways is she/he using it? For what purposes is he/she using it?

2. What do you think about his/her use of technology?

3. How does he/she use technology at home? What is available in the home? In what ways is technology used? For what purposes is she/he using it?

4. Did she/he have any technology assessments? Were you involved?

5. Does his/her use of technology affect the ways she/he interacts with others? In what ways does his/her use of technology affect these interactions?

6. Is there a difference between his/her actual use of technology at school and your expectations of its use for him/her?

7. Have you investigated different sources of funding for assistive technologies?

Summary of Technology Use for the 1991-1992 School Year: Part II

Respondent's Name: _____ **Date:** _____

1. What benefits has_____derived from using assistive technologies this school year?

2. What problems has _____had with assistive technologies during the school year?

3. What changes have you seen in _____'s use of assistive technologies? (This could be improvement or regression.)

4. How often, on the average, has _____ used assistive technologies during this school year?

5. Was the use of assistive technologies written in _____'s IEP last year? If so, what did it say? If not, are there plans for its inclusion next year?

6. Is there a specific academic area where _____ is more likely to use assistive technologies?

Teacher Questionnaire: Part III
Staff Training Questionnaire
1992-1993 School Year

1. What was your training for special education? Did you come into special education from another teaching area? If so, what teaching area was it?

2. How long have you been a special education teacher? What area is your specialty (e.g., TMH, EMH. LD, BD, or Cross-Categorical)?

3. What kind of training have you had for using assistive technologies (i.e., formal such as a workshop or inservice, or informal such as self-instruction)? Does the support staff in your classroom receive training for using technology? How do they receive their training?

4. On a scale of 1 to 5, with 1 being inadequate and 5 being excellent for your classroom purposes, how would you rate the adequacy of the software, hardware, and peripheral devices available for your classroom?

5. What procedures were used to select these devices and software for your classroom?

6. Why was (software title) or (peripheral device) chosen for _____'s use? (Look through field notes and ask about programs that you observed the child using.)

7. How often will _____ be using technology on the average per month during this school year? (This question is for teachers who will have the child again during the 1992-93 school year.)

8. Do you feel you need to use prompts for _____ to use technology? What kind of prompting do you use? Why did you choose that kind of prompting? Do you plan to fade its use? What is your plan to fade prompting over time?

Parent/Teacher Follow-Up Interview: Part VI

1. The last time we talked about _____, you had indicated/felt that (use a quotation form the technology interview.) Can you tell me a little more about those perceptions/feelings?

2. Do you feel that technology/computers has facilitated communication for _____? In what ways?

3. Can you think of any problem solving skills or concepts developed by _____ as a result of his/her experiences with technology? Can you explain?

4. It is often said that technology/computers assist children in their social interactions with peers and adults. Do you feel that _____has grown in these areas with the assistance of technology? In what ways?

5. You and the teacher/parent have noted that _____ has a relatively short attention span. How would you compare _____'s attention span between computer/technology use and other school or home activities?

6. In terms of social and emotional development, do you feel that _____'s self concept has been affected by his/her experiences with the computer? In what ways?

7. Do you feel that _____has become more independent as a result of his/her training with the computer and/or other technologies? In what ways?

8. Is _____somewhat more willing to attempt or initiate emotional and/or social activities now? In what ways? Did you see a relationship between his/her increase in activity initiation and his/her use of technology? In what ways?

9. Will _____ persist longer on computer/technology materials as opposed to, say, other education materials? In what ways?

10. Do you see any major benefits to you, _____, and the family as a result of the technology training? In what ways?

11. What would be the best overall descriptors of _____ as a result of his/her technology training?

12. Does _____ have more control over his/her environment (educational/family/social) through technology use? In what ways?

13. Does technology assist _____ in his/her functional activities?

14. Do you feel that the schools and other community/social agencies should be more involved in providing training for parents and insuring that the computer and technology is available to the child in the home? In what ways?

15. Do you think the family's/school's perspective on _____'s technology use is the same as or similar to yours? In what ways?

16. What kind of technology training do family members have?

17. What are the critical components of a technology program for _____?

18. In working one-on-one with _____ on and off technology do you see more positive behaviors and skills (such as better focus, attention, body positioning, more vocalizations, smiles, eye contact, social interaction) in activities using technology rather than in activities without technology? Can you briefly explain?

Macomb Projects (ACTT and TTAP Staff) Interview: Part VII

1. How did you begin working with _____?
2. When did you begin working with _____?
3. What kinds of activities and equipment did you originally use?
4. What progression was made because of his/her exposure to technology?
5. Was there integration of activities between home and school?
6. How long did you work with him/her?
7. What changes did you see in his/her use of technology? (Did you see a real progression of skills? Did you see that he/she had the ability to go to another level and he/she had an understanding of that level of technology use?)
8. How well did he/she use technology on a scale of 1 to 5, with 1 being totally dependent use and 5 being totally independent use?
9. When did you begin to have less frequent contact with him/her? Why?
10. Did some contact continue on a consulting basis? If so, how often? (Would you say that your contact has had an interval basis such as once a month, or once every 6 months, or something like that?)
11. What goals did you have for his/her technology use?
12. Summarize your experiences with him/her at school and at home.